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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · OCTOBER 24, 1960

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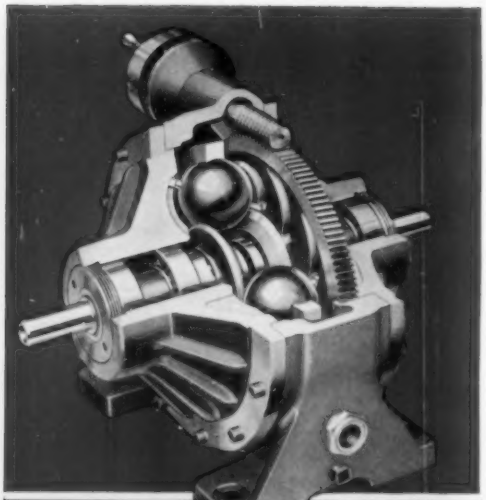
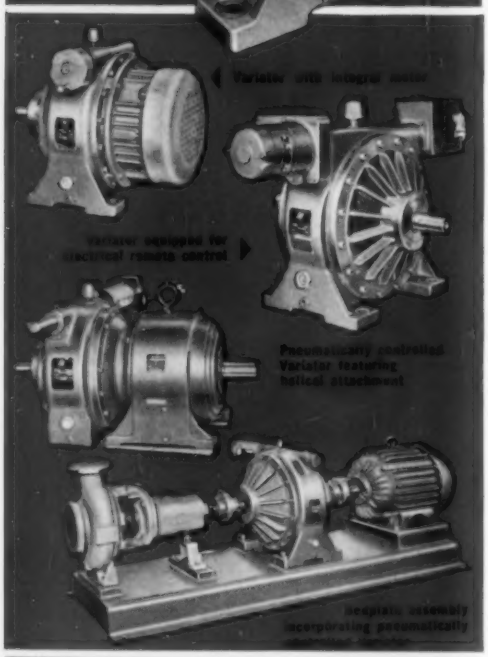
THESE FLUIDS FOR 500 F AND ABOVE . . . page 45
WHY NOT AC SWITCHES FOR AC CIRCUITS? . . . page 39





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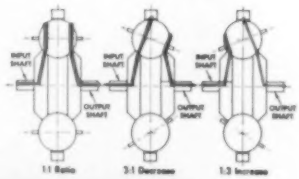

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

October 24, 1960 Vol. 31, No. 44

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MINNESOTA MR RUBBER

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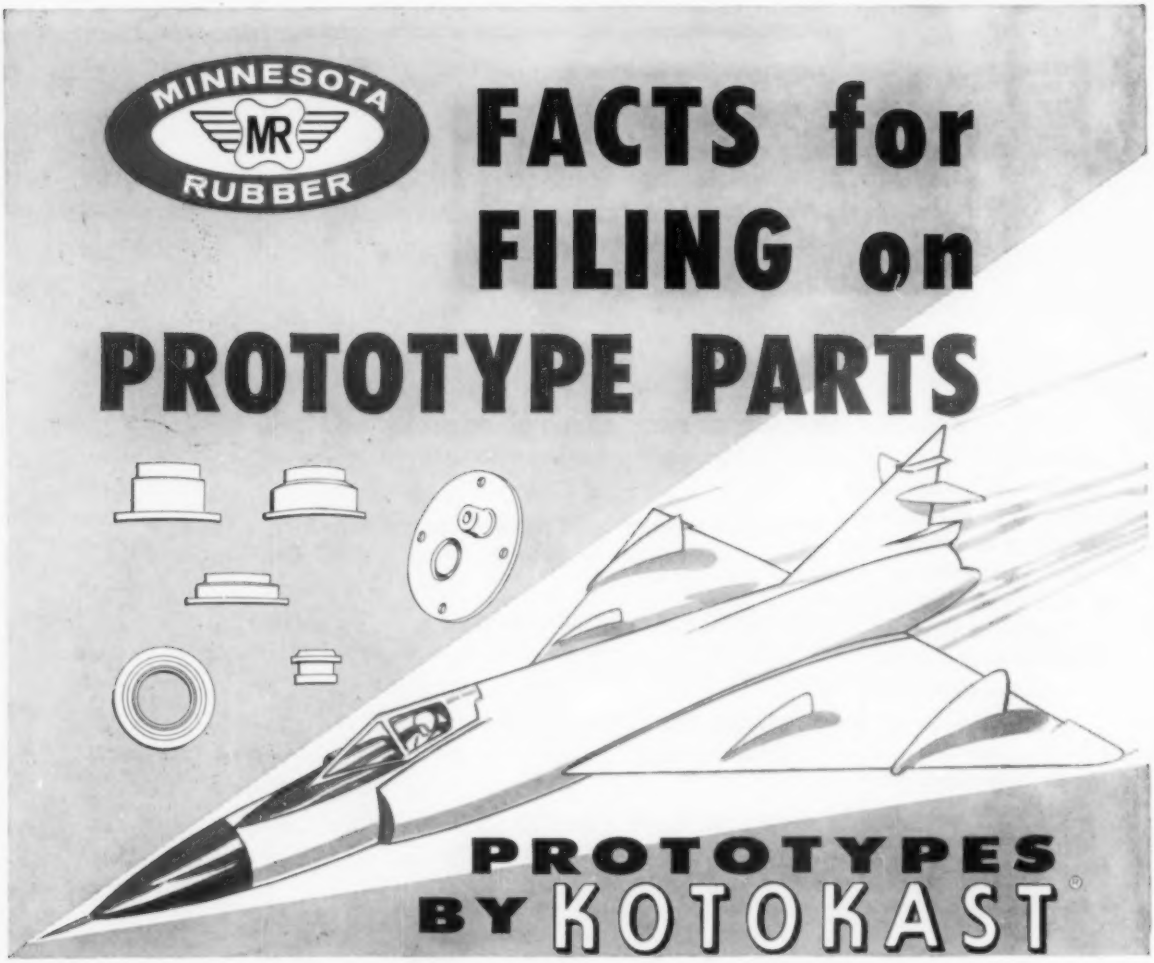

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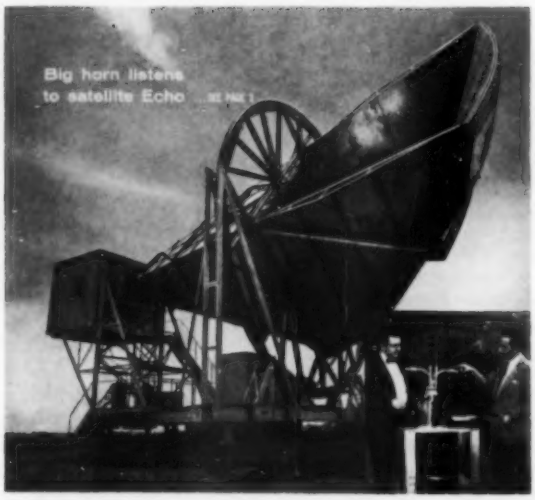

On our cover—the world's most sensitive microwave receiver, situated atop famous Crawford Hill in Holmdel, NJ. (It was also atop Crawford Hill, in 1932, that Karl Jansky first detected sounds from outer space. This discovery led to development of the radiotelescope.) The receiver on our cover was designed by Arthur B. Crawford, a radio research engineer at Bell Telephone Labs, for use in satellite communication tests. Recently, it picked up signals transmitted from the Jet Propulsion Laboratory in Goldstone, Calif and bounced off satellite Echo.

The inset shows Drs H. E. D. Scovil (right), leader in developing the first operational solid-state maser, and R. W. DeGrasse inspecting the receiver's maser amplifier. At heart of the maser is a 6-in., rod-like industrial ruby, contained in a waveguide cavity and closely coupled to a comb-like traveling-wave structure. These parts are surrounded by a magnetic field and cooled by liquid helium to −456 F. The maser generates 100 times less noise than comparable electron-tube amplifiers.

The associated circuitry in the sensitive hearing instrument applies negative feedback to a frequency modulation receiver. This principle was uncovered a quarter of a century ago by another Bell Lab scientist, Joseph G. Chaffee. In 1933, he jotted in his laboratory journal a new idea for an extremely low-noise radio receiver. "It never entered my mind in those days," Chaffee said recently, "that the receiver circuit might ever be used for space communications."

Joseph G Chaffee

Chaffee developed a mathematical analysis that confirmed his intuitive idea, then designed and built a laboratory circuit. He observed a tremendous decrease in noise and an improvement in fidelity. The invention was patented and written

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up in the *IRE Journal*; then the war took Chaffee into other research areas, and his idea lay dormant. With the need for improved space-age communications, Chaffee's special fm receiver was reinvestigated and incorporated into the satellite communication system.

The Wordiest War

On the 20th of December 1860 the state of South Carolina seceded from the Union. One hundred and fifteen days later the Civil War began. When it was over, some 600,000 lives had been lost in the costliest war in our history. (In World War II, 291,557 Americans were killed.) Next year will mark the Civil War's centennial. Homage will be paid to American dead on both sides of the Mason-Dixon line; some cities will hold ceremonies observing famous battle areas; National monuments will be decked with flowers. On the literary front, new books will continue covering the war in the most minute detail. At present, the New York Public Library has 520 ft of Civil War bookshelves. One estimate claims that the Civil War has been the subject of a book a day since 1861. And the presses go rolling along. Of all the books we've seen on that great war, the most informative is *The American Heritage Picture History of the Civil War*. The publishers say they invested over $2 million in this one book—that's about the same amount spent by the Union for one day's war activity.

Bruce Catton, who wrote the book's narrative, believes "the Civil War is the thing that makes America different. It was our most tremendous experience and it is not quite like anything that ever happened to anyone else . . ." The Civil War was also a period of great scientific advancement for America. The Union Navy built improved artillery in the form of the famed Dahlgren gun; the Confederate Navy could boast of the first submarine to sink an enemy vessel. Both sides floated the first ironclad warships. A Union physician designed and built the deadly Gatling gun, forerunner of today's machine gun. The Confederates used spring devices (p 52) to trigger a land mine, but everybody considered these inhumane and they were not heavily used.

A Brady photograph of the crew of the Monitor. Background: ironclad's famous Ericsson revolving gun turret.

In the field of communications, the Civil War fostered the birth of the Army's Signal Corps; the telegraph was a great aid to the Union. In fact, President Lincoln made the telegraph office in the White House his second headquarters. Thaddeus Lowe became the first man in history to direct artillery, by telegraphing enemy positions from a captive balloon high above the field of battle.

—Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Digital Readouts—a Special Report**

The basic types; how they work; how to make the right choice—with a selection chart to weed out the unsuitable types.

. . . **Allowable Stresses in Flash-welded Joints**

Formulas correlate fatigue data with magnetic inspection.

. . . **How to Draw Centerless Arcs**

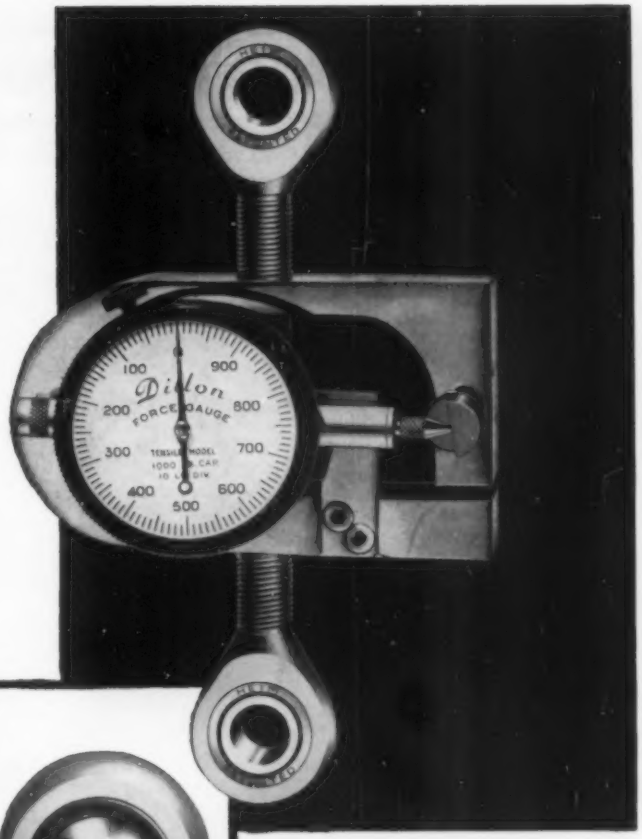
Two methods for laying out large curves when the centers are inaccessible and the use of trammels impractical.

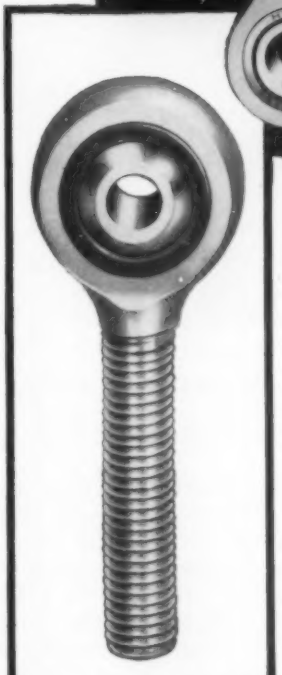
. . . **Effect of Cutouts on Machine-tool Pedestals**

Test results appraise 38 variations on a design theme.

This Success is No Secret...

The Dillon Mechanical Force Gauge is used for precision measurement of pressure, tensile or torque. For ease in applying load to tensile models, Unibal rod end bearings are attached to each leg of the alloy steel bar. If an oscillating, push-pull motion must be measured, both the compressive load and the tensile load are applied through Unibal rod ends.





Heim Unibal Male Rod End

In this case, an instrument calibrated 180 degrees in compression (reading clockwise), and 180 degrees in tensile (reading counterclockwise) is required.

Here is a true success story of a device, built with watchmaker's precision, which is designed to check all such loads, even in limited space.

It is no secret that the

HEIM *Unibal*® SPHERICAL BEARING ROD END

contributes to the successful operation of the Dillon Force Gauge. Two Unibal male-threaded rod ends are attached to the pressure bar. Calibration in both tensile and compression is conducted against a pin placed through the Unibal, or eye, of the rod end.

Heim Unibal corrects misalignment in every direction, reduces friction, carries maximum loads, saves time and money in assembly.

All Heim bearings are available through the leading bearing distributors in the U. S. and Canada. Send for complete catalog with distributors' names and locations.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

DEVELOPMENTS TO WATCH...

Midget motor designed for instrument use

A "flea-power" motor specifically designed for operation by atomic batteries (it's "transparent" to nuclear radiation) will soon be available for instrumentation applications. Automatics Production Research Co, which developed the device, says it will operate from ferroelectric generators, dry cells and isotope sources, and can be applied to timing, indicating, and similar functions. A 1-milliwatt motor weighs about an ounce, larger units are now being designed.

Navy developing controlled-radiation paints

Coatings for temperature control—paints that can help reduce absorption of radiant energy—are under development at Naval Research Lab.

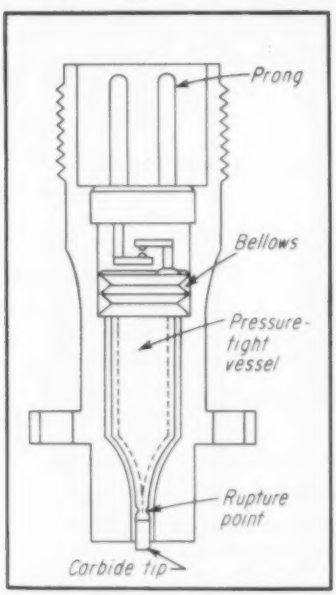
Primary aim of the work is an organic, paint-like coating that might be useful in maintaining the proper heat balance in space vehicles. The first step has been investigation of the effects of ultraviolet light on several such coatings under vacuum conditions. A report on this phase is being prepared and will be available in microfilm or photocopy from Library of Congress, Washington 25, DC as PB 146488 (NRL 5503).

The second phase of the study, now starting, will be a determination of the emittance characteristics of typical organic coatings. Results of this investigation will also be published when completed.

Cast iron approved for hydraulic equipment

Ductile iron scores again by getting the nod from the Navy as a casing material for hydraulic pumps and motors. Previously, only steel or bronze could qualify. Under a new regulation, grey iron will be acceptable too, if it meets or exceeds the standards of Federal Specification QQ I-652a, Class 40.

Overspeed control for machines uses frangible element



A nonelectrical "safety fuse" for machines, a device that operates mechanically to close an electrical circuit in the event of overspeeding which might, for example, cause a blade to strike a housing, has been developed by Englehard Industries, Newark, NJ.

Basically, the fuse is a pressure-tight bellows with a tungsten carbide tip (see diagram). Pressure on the unit expands the bellows; but under overspeed conditions, the carbide tip breaks off, relieving the pressure and allowing the bellows to contract, thus closing the circuit. One promising future application: aircraft turbines.

In a turbine application, the unit would be mounted so that there would be a slight, but only very slight, clearance between the turbine blades and the tip. Overspeeding and bearing failure would immediately cause the blade to strike the tip and rupture the pressure vessel.

Englehard has patented the device; but has not yet announced plans for commercial production.

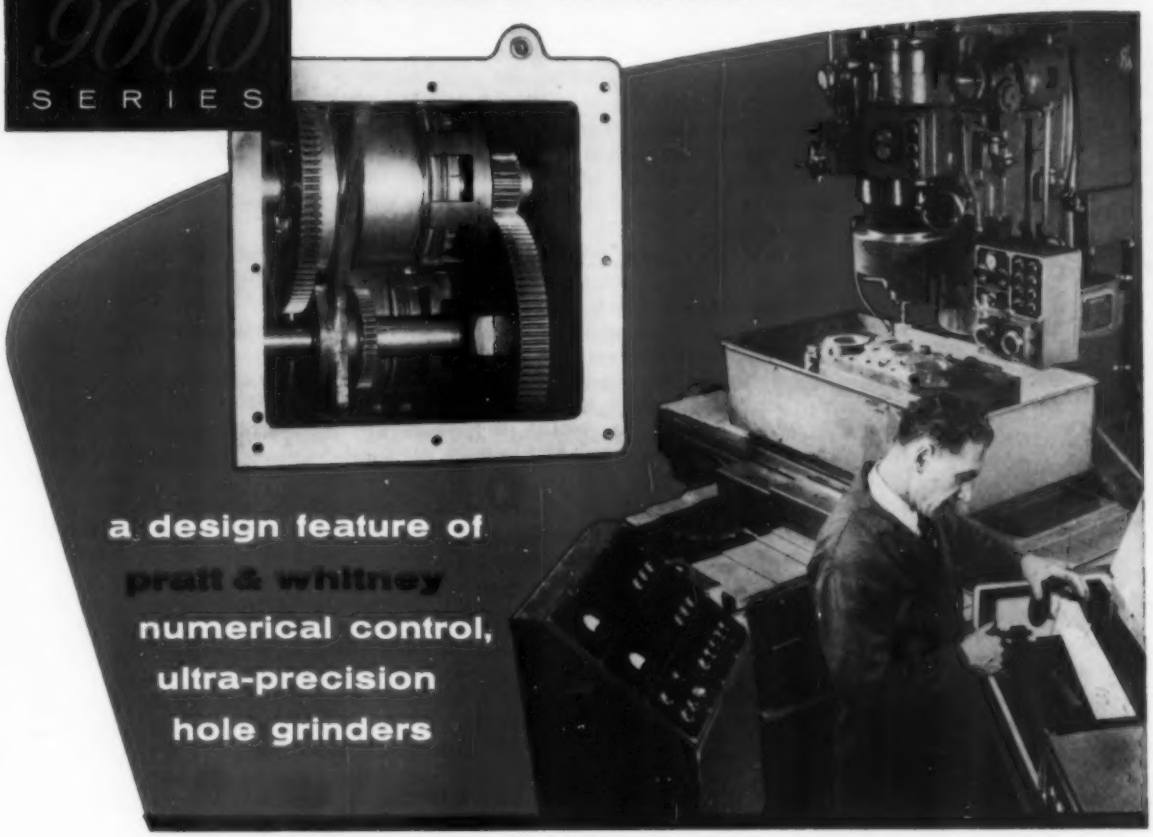
continued, p 8

FRANGIBLE FUSE for machines has pressure-tight housing comprising a bellows and carbide tip. The two parts can be combined into a single unit, as shown, with the tip attached directly to the bellows; or the two sections may be mounted independently, with a connection being made by capillary tube. A standard plug may be inserted in the end of the bellows housing to make contact with the prongs.

Maxitorq

electric clutches and brakes

9000 SERIES



a design feature of
pratt & whitney
numerical control,
ultra-precision
hole grinders

Again a famous machine tool builder favors today's outstanding electric clutches and brakes

Previously, Pratt & Whitney incorporated MAXITORQ Clutches in their high-precision jig borers. Proved performance led their engineers to test and accept the new 9000 series MAXITORQ Electric Clutches for their latest development . . . the fully automatic, numerically controlled, ultra-precision Vertical Hole Grinder and Electrolimit Jig Borers. Inset photograph above shows the compact and "clean" installation of two of these clutches in the carriage control drive gear box.

Incorporating new and advanced design principles, the 9000 Series MAXITORQ Electric Clutch is well adapted to machine tool drives. It is simple in design . . . built to machine tool standards . . . requires no adjustments. It can be used *either as a clutch or brake*. Disc separators not only separate discs but also break up residual magnetism, and result in extremely fast, positive action with no drag or heating in neutral. Design principles have been PROVED through years of service. There are few moving parts. Electrical operating unit remains stationary—hence, there are no troublesome slip rings or brushes; no difficult wiring problems. Clutches operate on standard 110 V a.c. converted to 90 V d.c. Other voltages on special order.

If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us.

Phone, wire or write Dept. PE-12 for new #9000 Series bulletin

The Carlyle Johnson Machine Company, Manchester, Conn.

Two-way freeze valve handles liquid metals and gases

To control the flow of molten metals and gases, two AEC engineers have designed an ingenious system that is valved by a plug of the metal itself. Among its advantages: elimination of corrosion that may be encountered when other metals are used for valving; a system leaktight both to the metal, and gases used for propelling it.

No moving parts are involved. The system simply sets up, on the pipeline, a heating area to liquify the metal, a cooling area to freeze the plug, and a system for removing entrained liquid or vapors to ensure that enough liquid will be available in the hot zone to form a tight seal when the material reaches the cooler.

The valve is U-shape, with base of the U serving as the hot-cold area, and the legs as the de-entrainment zones.

A cylindrical, double-walled casing forms base of the U and provides a wall for the liquid. The cooler is installed at one end of the casing. It, too, is a double-walled unit, through which cooling air or water flows.

The legs of the U contain a pair of bubble chambers and conduits that connect to the base section. Resistance heaters are provided to keep the metal liquid.

To start the flow, the bubble chamber is heated and the metal moves through the heated valving section. To stop it, the heaters are simply turned off.

When the unit is used to handle a gas, the metal that serves as a plug is simply melted away and removed by a bypass, being fed back through the bubble chamber when the valve is to be closed.

The system can be used, says AEC, for almost any metal melting below 1000 F.

The device, one of many developed for handling liquid metals (see p 45), has been patented and is available for royalty-free, nonexclusive use.

Chemical-energy storage to replace batteries?

Thermochemical energy-storage systems are receiving renewed attention for space use at Allison Div of GM. These systems store energy by melting a compound which has a high latent heat of fusion. During periods of sunshine (heat supply), the compound absorbs energy and melts. When heat is removed (that is, when the sun's rays do not strike the collector), the compound "freezes" and liberates the stored energy in the form of heat. The idea is by no means new. Such systems were used in the first solar-heated houses. But Allison engineers believe they deserve more attention for engineering applications.

A thermochemical system, using lithium hydride as the storage compound, could achieve a storage capacity of 150 watt-hr/lb and an over-all energy-conversion efficiency (with a mercury vapor turbine or Stirling cycle engine) of 15 to 45 watt-hr/lb. This is small compared to the 300 watt-hr/lb performance expected of fuel cells. But it compares favorably with the present-day output of rechargeable silver-zinc cells (30 to 40 watt-hr/lb).

Eventually, the silver-zinc cells may reach 60 to 80 watt-hr/lb. But the lithium hydride systems are subject to improvement too. The Allison engineers think they should be able to reach at least the 60 watt-hr/lb level.

New source for an up-and-coming metal

Rubidium, the "unknown" alkali metal now under test for applications ranging from heat exchange to ion propulsion (*PE—July 25*, p 9), gets a new booster as MSA Research Corp becomes a primary supplier.

No one could call rubidium a low-cost material. But MSA's present price—$350/lb in 10-lb lots—brings it into the same range as germanium and gallium. It has already found at least one practical commercial application: The rubidium magnetometer developed at National Bureau of Standards is now being produced commercially by Varian Associates. This unit takes advantage of the extraordinary stability and predictability of the oscillations of rubidium atoms to measure and compare applied magnetic fields. Now under development by Varian are new rubidium frequency standards ("atomic clocks") that take advantage of the same characteristic.

Work on rubidium as a boiler fluid is underway at several companies, including MSA and Aerojet-General; and new alloy systems, such as the low-melting rubidium-and-sodium eutectic (melting point is zero deg F) are under investigation. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Bellows-operated "shutter" solves heat-disposal problem

In designing equipment for outer space a special problem is faced in disposing of heat in a vacuum. Convection can't help. The only method is radiation, and the problem is complicated by varying rates of heat generation.

In nuclear thermoelectric energy-conversion devices, for instance, heat output is high when the unit starts up, but gradually drops as the "fuel" is consumed.

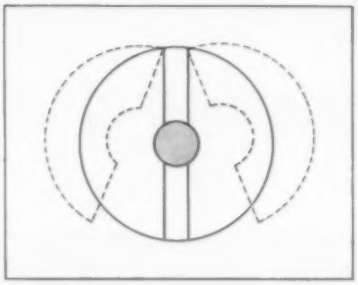
To solve the problem, Martin nuclear engineers have devised a simple but effective bellows-type device that will be used with the SNAP 1-A nuclear reactor.

The bellows, split and hinged, are preloaded on one side by a constant gas pressure, and exposed on the other to mercury vapor which serves as the reactor coolant. When the reactor is "cold," the bellows are shut. But, as the reactor heats up, the mercury vapor pressure increases, activating the bellows and opening a "shutter" via a clamshell gear system, permitting heat to radiate.

Martin engineers considered several other approaches, among them, electrical systems and controlled gas leakage. But the electrical systems would have imposed too great a load on the energy output of the unit, and might also have been subject to radiation damage. Controlled gas leakage (allowing some of the coolant gas to escape) might prove suitable for smaller reactors, but did not seem satisfactory for the larger units now being designed. The "shutter" diagramed above proved to be the best answer.

More pneumatics to replace electronics and hydraulics

Pneumatic switches for computers, and gas-operated controls to replace electrical and hydraulic units in missiles, are being developed both in this country and the USSR. The pneumatic devices don't work as fast as electrical or electronic relays; but they can be operated at high temperature, and promise to be more reliable than many computer components.



CLAMSHELL SHUTTER, in open (dotted lines) and closed position, shields heat-dissipation point.

The new computer elements, designed at the Moscow Institute of Automation and Telemechanics, are pneumatic relays, created by interacting air jets.

In a report on the work, the British publication *New Scientist* says such pneumatic switches can be used to store information in much the same way as conventional electronic relays, and all-pneumatic digital computers are being designed for automatic control installations in oil, chemical, and steel plants.

The pneumatic controls are suggested by Battelle Memorial Institute as one solution to the problem of providing flight-stabilization systems that will operate at high reentry temperatures. Pneumatic systems are generally considered low-performance devices, useful primarily where reliability is more important than speed. But, as John Wetherbee of Battelle points out, this limitation can be removed by operation at higher pressures and higher temperatures, as would be desirable in missile applications.

One example is the hot-gas servo, already in successful application. However, these servo systems still are limited by the temperature limitations of currently available electromagnetic input and control systems. One possible solution: "pure fluid amplifiers." Interacting jet steams very similar to those being proposed by the Soviets are already under test at Diamond Ordnance Fuze Laboratories, and their response speed, while not as fast as that of an electronic amplifier, may still prove to be sufficient for the applications under consideration.

Corrosion resistance of tantalum likened to glass

The corrosion resistance of tantalum is remarkably similar to that of glass, L. A. Fink of Battelle Memorial Institute told the AIChE annual meeting—so much so that tantalum can be used to patch glass equipment.

Tantalum is inert to most acidic solutions, chrome-plating solutions, most salts, and many liquid metals. However, tests show it is not very resistant to alkalis, except in low concentrations, and is attacked by most gases at 600 F and above. Tantalum is also subject to hydrogen embrittlement. "Even at room temperature," says Fink, "atomic hydrogen liberated by corrosion of an anodic material is readily absorbed. For this reason, care should be taken not to couple tantalum to any other metal."

briefs . . .

Rubber, custom-tailored "on the vine," may be one of the first new developments to come from the natural-rubber industry's promised research program (*PE*—Oct 3, p 8).

Rubber with substantially higher tensile strength and better compression set can be produced on a practical commercial basis "at the plantation level," Goodyear believes. Either high-energy machines or radioisotopes may be used, and tests indicate other characteristics also may be improved.

Image "dissection" is helping to take more pictures faster, J. S. Courtney-Pratt of Bell Labs told the SMPTE meeting (*PE*—Oct 17, p 26). In this ultrahigh-speed photography system, split lenses are used to break up the image into a large number of small elements and space them out across the film. All of the elements of one image are recorded simultaneously, with successive images being recorded on the same frame. For each succeeding image the film is slightly displaced so that the elements of succeeding images fall in between those of the first. This way, several images can be recorded on a single frame, permitting a much higher rate than can otherwise be achieved. —ARG

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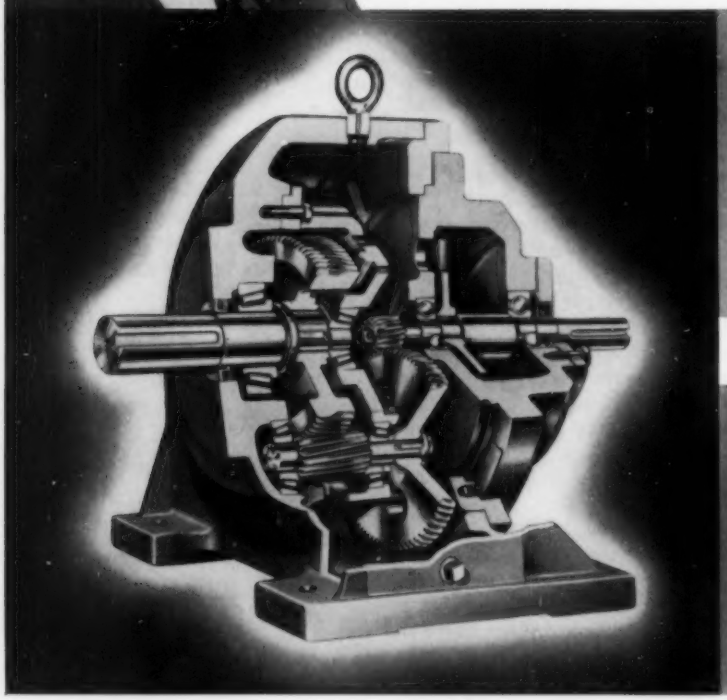
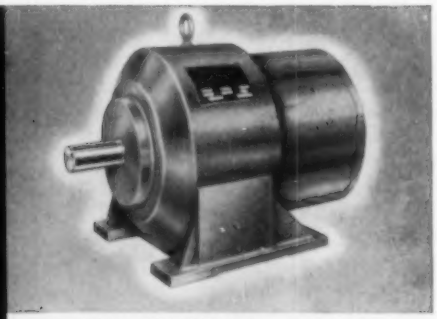
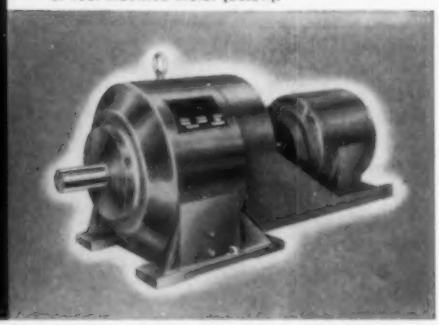




Available as "IN-LINE" Reducer (left), or as a GearMotoR with flange mounted motor (above) or foot mounted motor (below).



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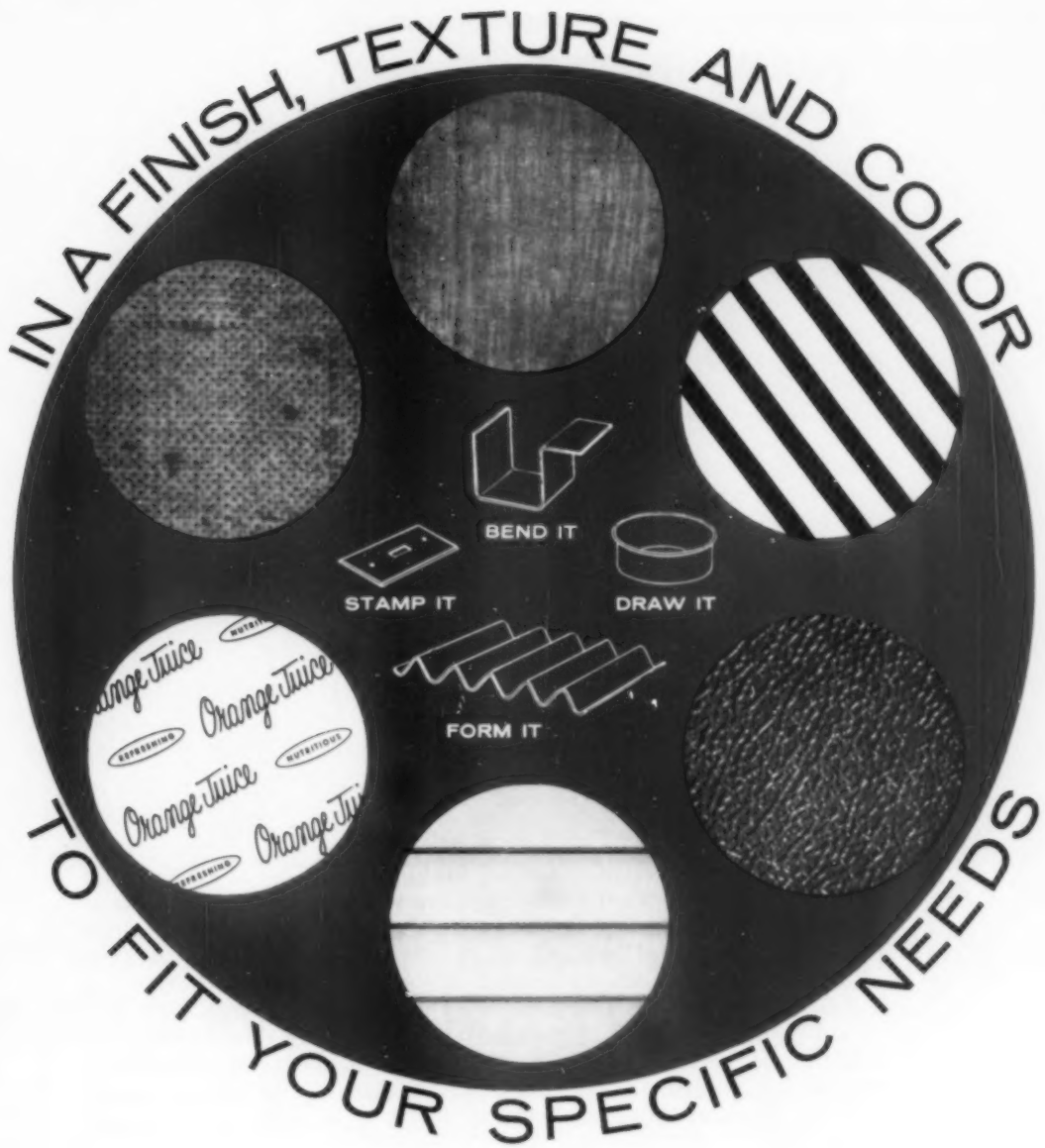

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CIRCLE 11 ON READER SERVICE CARD

FROM WASHINGTON . . .

Congress frowns on high recruiting costs

A House subcommittee on manpower utilization has taken a look at the cost of recruiting engineers and found that firms depending heavily on government contracts are spending too much.

For its survey, the House obtained data from 102 companies having defense contracts in 1959. **Of these, 76 did more than 50% of their business with the government. Their recruiting costs averaged $1022 for each new engineer or scientist hired. The 26 remaining firms, whose business was over half commercial, averaged $751 for each engineer hired.**

Four firms, three of them predominantly government contractors, spent more than $2000 for each individual hired. Eleven of the firms spent between $1500 and $2000 per recruit. All but one of the latter companies was government-oriented.

In its study, the subcommittee also eyed turnover of engineers on defense contracts. It found that turnover for government contractors was about in line with commercial firms except for companies doing business with the Army. **Army contractors lost about 22% of their engineering employes in 1959, against 14% for firms doing mostly commercial work.**

In a statement following release of the report, James C. Davis, chairman of the subcommittee, called upon the Defense Department to give greater attention to recruiting costs when negotiating contracts. He also said that effort should be made to reduce turnover in a few firms showing excessively high rates. Such turnover, Davis noted, adds considerably to the cost of recruiting.

$23 million for space platform is only the beginning

The first design and development contract has been awarded for an orbiting space platform. **Grumman Aircraft Engineering Corp was selected over 11 other companies to develop a 1½-ton orbiting astronomical observatory, with the first flight model to be delivered in 2½ years.**

Grumman's proposal calls for building two 8-sided satellites 9½ ft high and 6½ ft dia. Each will weigh 3200 lb including 1000 lb of instruments.

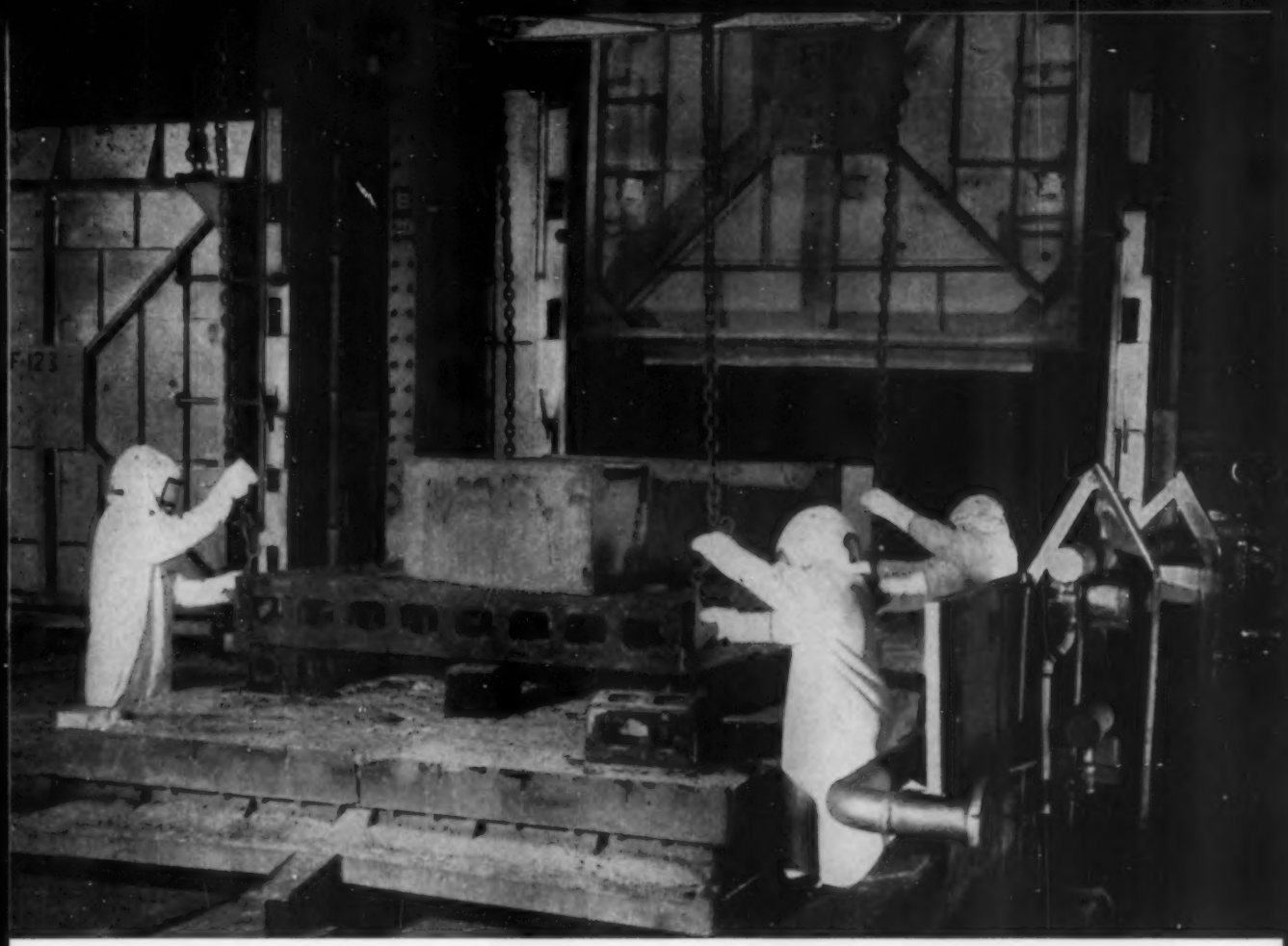
The $23-million Grumman contract marks the beginning of a series of contracts to be let over the next few years for the so-called "exotic" equipment destined for space use. **Included are additional space laboratories, and mobile "trucks" to be landed on the moon—for exploring 50-mile areas under remote control, and the like.**

Ground equipment becomes key to satellite success

Within the next five years, the experts say a satellite communication system, navigation system and meteorological system will be in service. Each will require large amounts of specially designed ground equipment to tap and use the data flowing from the satellites.

One example is the Navy's satellite navigation system due to be in service by 1962. This will consist of four satellites in equatorial-stationary orbits. They will be 22,300 mi high, matching the earth's rotation with their speed so that they, the satellites, do remain in one position over the earth's surface. The satellites will transmit continuous signals allowing ships or submarines anywhere in the world to obtain positions every 1½ hr with ½-mile accuracy.

Some 1000 Navy vessels that fall in the major ship category will have to be outfitted with special receiving equipment to use the system. The system also will be made available to all commercial ships. There are perhaps 1000 ships in the worldwide merchant marine fleet that potentially will need receiving equipment.



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If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania. No obligation of course.

This main axle casting for the 60-cubic yard Mountaineer Shovel was cast in a Blaw-Knox Steel Foundry. Wt.—18,000 lbs.

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CIRCLE 13 ON READER SERVICE CARD

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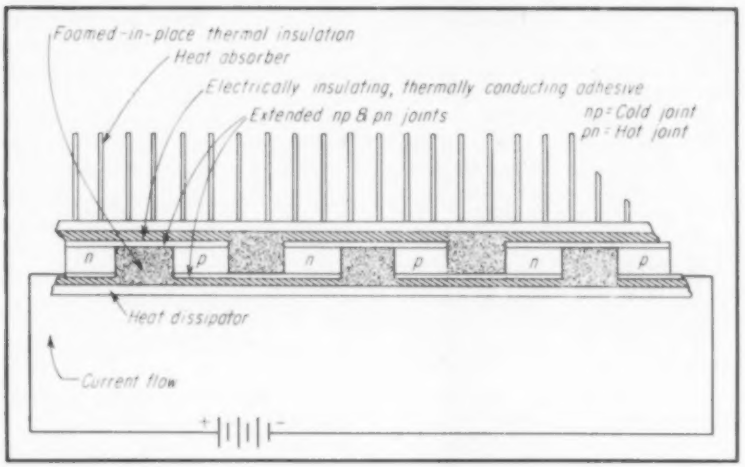


Path to Electrothermal Cooling Gets Warmer

St Joseph, Mich—Electrothermal cooling, long a laboratory curiosity, will soon be providing safe and silent refrigeration for submarines, according to Whirlpool Corp research lab engineers here. Later on, they say, a much wider field—including air-space and general consumer products—is expected to result from a research program variously sponsored by the Navy and individual US companies.

Current Navy research and development efforts have two main objectives: finding more efficient materials; and design, test, and pilot production of suitable "hardware." While research in materials continues, design and test of electrothermal cooling units has reached a fairly advanced stage.

As developed at Whirlpool, the cooling unit is of modular design (see illustration above), each module being substantially a sandwich structure, having a hot and cold face. Between the two thermal skins are arranged Peltier couples made of bismuth telluride buttons doped to produce positive and negative ("p" and "n") electrothermal power.

Foamed-in-place insulation helps reduce heat losses in the core, while a vapor barrier, later applied to the edges of the sandwich, prevents breakdown of the couples as the result of humidity-induced corrosion.

In a particular design, heat is removed from the hot surface by flowing water, while the heat-absorbing (cold) surface is extended into fins in order to provide a larger heat-transfer area.

EXTRUSION, CASTING FAILED

Finned surfaces were developed for Whirlpool by the Wolverine Tube Div of Calumet and Hecla. After attempts to extrude them and to cast them proved unsatisfactory, the company simply grooved an aluminum plate of the desired dimensions, inserted cut strips of rolled aluminum into the grooves, then rolled the edges of the grooves to lock the strips in place.

A cooperative basic research program sponsored by 20 companies is being conducted at Philadelphia's Franklin Institute. This effort is aimed at discovering the laws governing the phenomenon of electrothermal cooling, so that materials can be tailored to do the job effectively.

—Felix Giordano

AIR Force Planning to Do It's Supply Shopping Electronically

New York—The Air Force will soon be using an automatic communications network to requisition parts and supplies for its various installations around the world. The network was developed by Western Union and, when installed, will be leased to the Air Force for $22 million annually.

The communications system, known as Comlognet, will be built around five control centers at various locations throughout the country. They will receive and transmit messages tying together 450 air bases, air stations, depots and civilian suppliers, here and overseas.

When in full operation early in 1962, the system will be capable of transmitting up to 3000 words per min. A requisition can then be transmitted almost instantaneously from an operating base to an Air Force warehouse or civilian supplier. And, where speed is imperative, the part can be airlifted back to the base.

One of the key problems in developing Comlognet was to design a control center that would be capable of translating messages from the language of one type of machine into a language that could be understood by another type of machine. That is, the control center had to be able to receive a message from, say, a teletype at the user end and translate it into the language of a card reader at the supply end.

Such versatility is necessary because many types of very expensive equipment are already in service at various civilian and military installations. Comlognet will be able to handle data from such machines as punch-card readers, magnetic-tape transports, digital computers, and paper-tape transmitters. It will also be able to handle analog signals and digitalized voice and graphic signals (weather maps, for example).

Great emphasis has been placed on accuracy. The switching centers include automatic accuracy-control devices to ensure that during transmission of 10 million characters, no more than one error goes undetected.

Comlognet has two major types of transmission circuits: message switching and circuit switching. In message switching, electronic equipment at the control center stores the entire text

of an incoming message, then automatically switches it to an outgoing circuit. In circuit switching, a direct connection is set up between sander and receiver, and the message passes through the control center without interruption. Circuit switching is a faster, more advanced technology. Initially, four of the centers will have 50 each; the fifth center will have 100 message-switching and 50 circuit-switching channels. Each can be expanded to 100 message-switching and 200 circuit-switching channels.

The control centers are designed around modules, hence expansion can be accomplished by adding modules as message volume increases. According to Western Union, the system ultimately may be expanded to handle many millions of communications concerning aircraft movements, air-traffic maintenance, passenger information and flight-control data. Long-range plans also call for inclusion of financial, medical, personnel and statistical reports. Such reports account for 24 million communications annually. Requisitions call for about 19 million communications annually. ■

New Way to Bend Thin-wall Aluminum

A method of bending 8-in.-dia thin-wall (0.044) aluminum tubing to a 2.5-D radius has been perfected at Boeing Airplane Co's division at Wichita, Kan. Tooling, soon to be completed, will allow 2-D bends (and maybe even 1.5-D bends) on heavier wall material. Large tubing sections can be applied to irrigation, air-conditioning and electrical installations.

Britain Raps Its Own R & D Growth Rate

LONDON—Although British R & D activity is expanding at an encouraging rate (40% in 3 years), the scale of effort is still inadequate and unbalanced, according to the recently published annual report of the Advisory Council on Scientific Policy.

In 1958, the report states, the UK spent about $1340 million, representing 2.35% of the gross national product (GNP), on R & D while the US spent $11,160 million representing 2.74% of the GNP. Allowing for differences in defense expenditure, the committee says expenditure on civil R & D is about 1½% in each country.

British applied science and technology still shows large gaps where the entire research and development effort is much too small, according to the report, which goes on to say that the great difficulty is finding suitably qualified research personnel, especially in branches of engineering where the university research tradition is weak.

Specifically, the report names the economic production of new materials, conducting, semiconducting, insulating, magnetic and structural; and the improvement of existing ones, as a field where research must be intensified, a move which will require "much improved collaboration between chemists, physicists, mathematicians and metallurgists both in universities and in industry," says the report.

The general problem of collaboration, such as dovetailing traditional scientific disciplines without leaving gaps, of organizing "hybrid" studies, and of collating and disseminating scientific information, occupied much of the committee's attention. The rather surprising conclusion was that the "existing traditional pattern (of scientific organization) is in broad outline satisfactory." Existence of a civil "development gap" between research results and industrial application, so often a fly in the ointment, was admitted, but no firm measures were recommended for its closure.

The deficiencies of British scientific education received another airing. Said the report, "It has been suggested to us that up to 20 or 25% of the content of the curricula in physics, chemistry and biology could be eliminated without any harm; indeed with benefit. Mathematics curricula are equally in need of revision." Over-specialization too early is a latter-day fault caused by the teacher's desire to cover subjects in depth, stated the report, but if the curricula were revamped without adding new material, then more time would be available for studying general subjects.

—Nick Landon
London Bureau

You Can Now Tune in on Microfilm

NEW YORK—A system permitting a person miles from the central transmission point to instantaneously view microfilm material on a high-resolution TV screen has been developed by Nord Photocopy and Electronics Corp. Called Microfilm Video Transmission, it gives the viewer control of the transmission unit through remote-control equipment at his station.

Scanning the microfilm, he can select any section of the film he wishes to examine and then electronically enlarge that portion as much as 60 times' microfilm-aperture size.

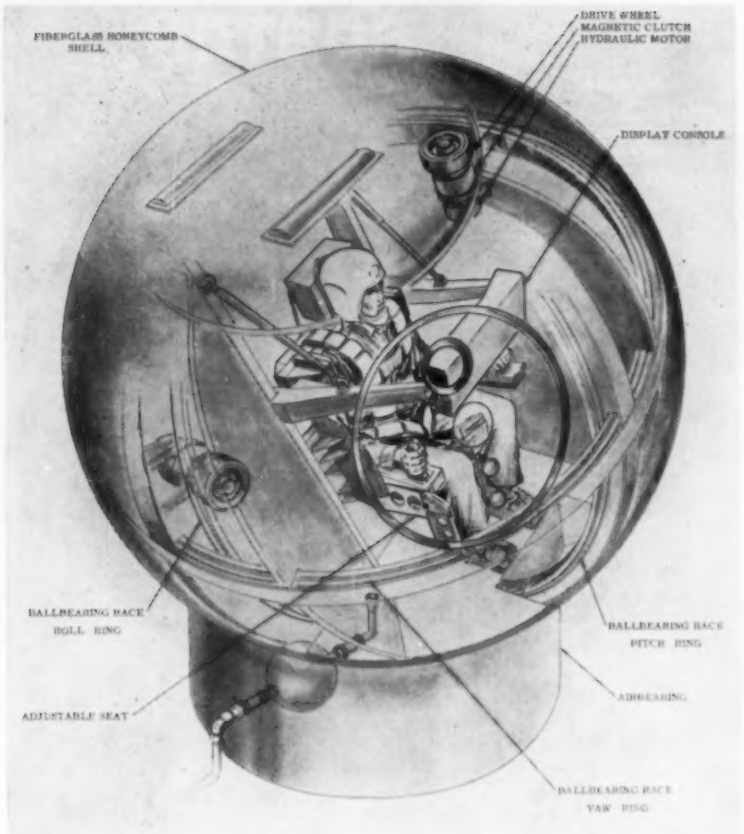
For greater clarity and detail, the system uses 945 scan lines, compared with a 525-line system in US commercial TV. The present model employs a special phosphor on the receiving tube, for clarity of picture.

In the Nord system, the microfilm slide is scanned by a fast-moving beam of light emanating from a specially adapted cathode-ray tube. As the light beam passes through varying shaded areas of the film, its intensity is changed. These changes are interpreted by a photoelectric cell and translated into equivalent electrical impulses.

After being greatly amplified, the electrical impulses are mixed with synchronizing impulses in a "sync" generator to lock the outgoing picture in step with the transmitter. This composite signal is then fed into coaxial cable and distributed to any number of locations. These can be preselected by the operator of the transmitting unit.

The complete transmitting unit, including built-in monitor, is expected to sell for about $12,000. Monitor units with remote control—$2000.

Rotating Ball Simulates Satellite Flight



A 10-ft-dia fiberglass ball, riding on a cushion of air, will permit investigation of the reaction of modern man to complex rotation in space. The 4300-lb simulator is being developed by the Air Force to check mental and physical limits of astronauts under extreme rotational conditions up to 70 rpm. It will also help answer other human tolerance questions. Simulator is constructed of bonded sandwich-type fiberglass honeycomb. It will ride on a virtually frictionless circular stream of air 6 feet dia. Control and rotation is provided by three inertial rings rotating within the inner surface of the sphere. The rings are mounted on the axes of roll, pitch and yaw and powered by a 20-hp motor. Designed by Northrop Corp's Norair Div, Hawthorne, Calif, and currently under construction there, the flight simulator will be installed at the School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, San Antonio.

Britons Argue Setting Up Government Automation Center

LONDON—"Should Britain have a national automation center?" This question has again flamed into public debate here, as a result of support given to the proposal by two professors, E. J. Richards of Southampton Univ and R. H. MacMillan of Swansea Univ.

The proposed center would operate under government supervision with an initial staff of 200 drawn from industrial research labs, government and the universities. It would include five or six theoretical-research sections and data-processing sections for each major industry. The center would also run an advanced control-engineering course and publish its own automation journal.

Opponents of the scheme argue that an adequate research structure already exists. The government sponsors a National Physical Lab as well as industrial research associations for each industry. All that is needed, they say, is to reorient these existing units toward automation. A national center would be a waste, they add.

Piezoelectric Ignition to Spark Small Engines

CLEVELAND—A totally new source of electricity for ignition systems in small engines is now available, according to engineers of the Cleveland Graphite Bronze Div, Clevite Corp.

It is a piezoelectric transducer that creates a spark twice as powerful as that produced by an ordinary magneto and condenser for such compact power equipment as power lawnmowers, outboard motors, portable generators. The new device, no larger than a man's thumb, contains two ceramic parts that convert a single, short motion into a 20,000-v charge.

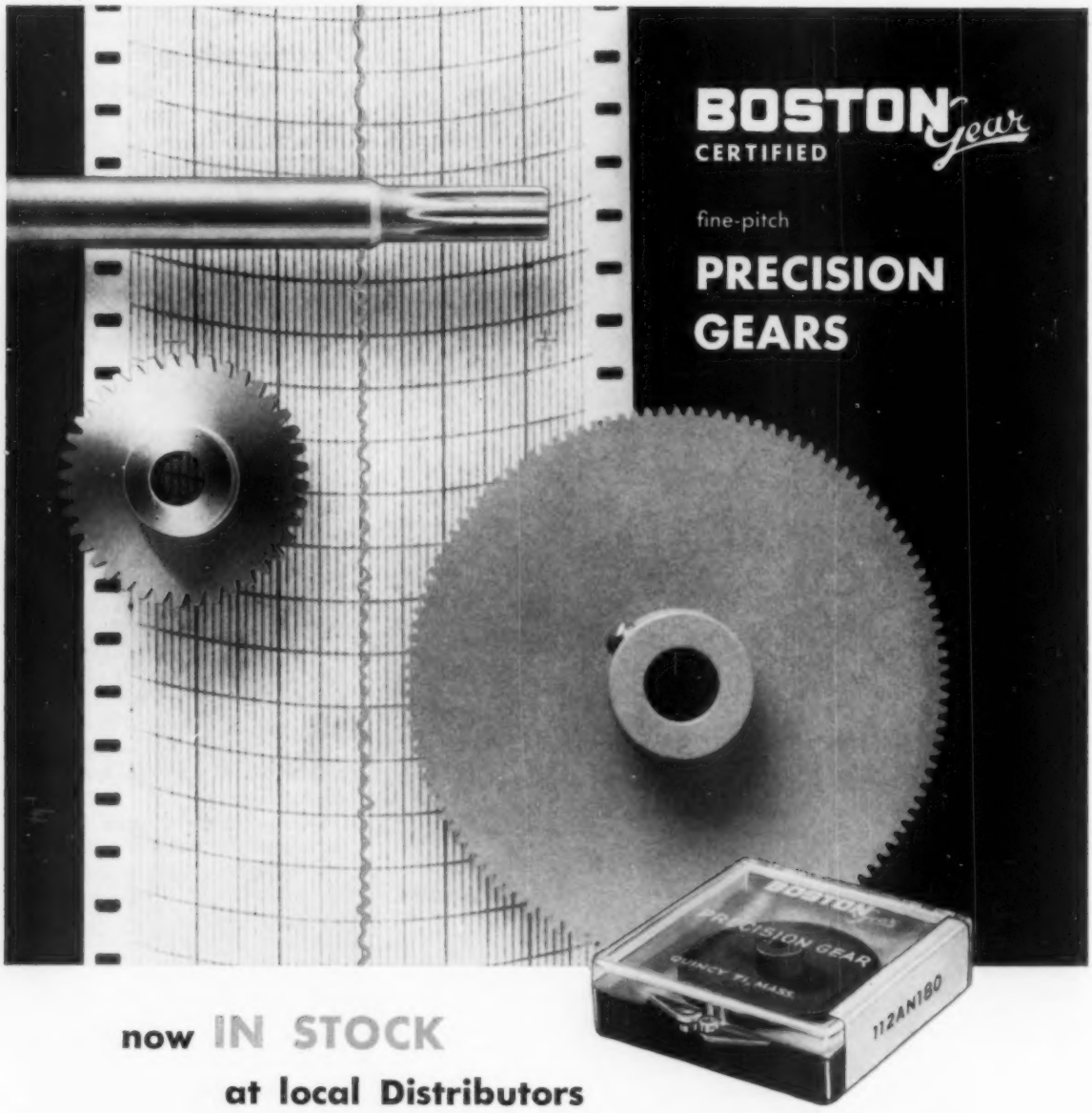
Clevite calls the device a "Spark Pump" because it produces a spark each time pressure is applied to it. The transducer, a switch and a sparkplug constitute a complete ignition system for a small motor.

Besides simplifying the ignition process, the transducer produces a constant high voltage at all engine speeds. This means that many engines can be started with a single turn of the familiar starting cord, without the need for complex starting mechanisms.

In two years of tests, Clevite's device has proved able to fire a heavy spark through a sparkplug even though the plug's electrodes were burned or fouled. A demonstration model, when squeezed with ordinary handshake pressure, generates a spark hot enough to jump across a ¼-in. gap.

Basis for the new power source is the fact that some natural crystals, such as quartz, will emit a tiny electric current when twisted or bent. Cut into paper-thin slices, such piezoelectric crystals have long been used as the pickup elements that translate phonograph-needle vibrations into electrical impulses that are amplified and played through a loudspeaker. Clevite grows these crystals artificially, and in recent years has developed "PZT" ceramic crystals that do the same work better.

"The possibilities of the Spark Pump are by no means fully explored," says Clevite. "Our development program will continue at full speed to make the device still smaller and simpler. But we are satisfied that it is a fundamental improvement in engine ignition, and we are moving into initial mass-production." ■



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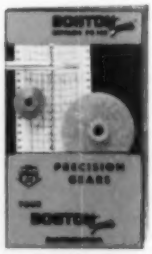

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Monsanto's new FluiDesign Service—established to help you meet your needs best from the capabilities of some thirty specialized fluids—can give you valuable guidance at the outset of your design exploration and engineering planning. For example, the next two pages provide you with the FluiDesign Service Report, "Fire-Resistant Fluids for New *Mechanical* Applications." Among the fifteen fluids described, one or more may allow you to engineer your next design for safer, more efficient performance.

Be sure to get your fact-packed Fluid Data File . . .

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The fifteen fire-resistant fluids described here are now at work in industrial and aircraft hydraulics, heat transfer and other mechanical applications which require a firesafe fluid. When you need a fire-resistant fluid for any application, one of these Monsanto specialized fluids may be adaptable to your job.

Consider how these and other specialized fluids might solve special-design engineering problems for you. If one of these fifteen does not meet your present requirements, Monsanto FluiDesign Service will make other recommendations for your application. Just send a brief description of the conditions which your fluid must meet.

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	Skydrol 7000	Skydrol 500A	Pydraul 60	Pydraul 150	Pydraul F-9	Pydraul A-200
Flash point, °F., Cleveland Open Cup	425°	360°	435°	380°	430°	380°
Fire point, °F., Cleveland Open Cup	475°	425°	460°	470°	675°	680°
Autoignition temp., °F.	1050°	>1100°	>1000°	>1100°	>1100°	>1200°
Viscosity, cs. 100°F.	15.5	11.5	11.1	30.8	47	49.5
210°F.	4.00	3.92	2.65	8.0	5.5	4.8
Pour point, °F.	< −70°	< −85°	−70°	−55°	−5°	10°
Boiling point, °F. 760 mm. Hg	709°	—	707°	617°	644°	620°
Max. bulk temp., °F. long term	200°	225°	200°	200°	300°	300°
Coefficient of thermal expansion, per °F.	0.00042	0.00045	—	0.00042	0.00041	0.00040
Specific heat, 25°C.	0.42	0.38	0.42	0.40	0.32	0.28
Thermal conductivity Btu/hr./ft.^{2}/ft./°F.	0.0723	0.0777	0.047	0.070	0.067	0.059
Bulk modulus, psi	328,000	308,000	328,000	319,000	387,000	400,000
Specific gravity, 25°/25°C.	1.08	1.07	1.09	1.13	1.28	1.42
Resistivity, ohm-cm, 25°C.	5×10^8	4×10^7	—	—	1.5×10^9	3.3×10^{10}
Dielectric strength, 25°C., 60 cps., 0.1 in.	36KV	12KV	—	—	33KV	38KV
Dielectric constant, 25°C., 1000 cps.	8.87	8.81	—	—	6.25	—
Power factor, % 1000 cps., 25°C.	0.49	—	—	—	2.2	—
Original use	aircraft hydraulics	aircraft hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics

MECHANICAL APPLICATIONS

phosphate esters, silicate esters, diphenyl and terphenyl and chlorinated derivatives. Monsanto has the best facilities and broadest know-how for making the widest variety of fluid "base" stocks and additive modifiers of any chemical manufacturer. Whatever your requirements, consult Monsanto if you need a fluid for a new product or machine-design concept.

Write:

MONSANTO CHEMICAL CO.
Organic Chemicals Division
FluiDesign Service, Dept. 2764B
St. Louis 66, Missouri

SKYDROL, PYDRAUL, AROCLOR: Monsanto T. M.s, Reg. U. S. Pat. Off.

Pydraul 625	Pydraul AC	OS-81	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Transformer Askarel
465°	420°	—	295°	308°	360°	379°	—	460°
745°	650°	—	349°	460°	>610°	>640°	>660°	460°
>1100°	1100°	1100°	>1000°	>1100°	>1200°	>1200°	>1200°	1000°
135	88.2	35.25	4.6	6.9	17.2	45.3	500	5.0
6.1	5.15	3.18	1.2	<1.8	2.5	3.2	6.14	1.5
20°	20°	15°	34°	−32°	2°	20°	50°	47°
724°	688°	—	527°	554°	617°	644°	689°	460°
300°	300°	300°	600°	600°	600°	600°	600°	600°
—	0.00040	—	0.00039	0.00040	0.00038	0.00039	0.00037	0.00039
—	—	0.31	0.33	0.31	0.29	0.27	0.26	0.25
0.065	—	—	0.067	0.063	0.058	0.057	0.054	0.050
375,000	375,000	—	—	—	—	428,000	—	—
1.36	1.35	1.40	1.18	1.26	1.38	1.45	1.54	1.57
—	—	—	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	5×10^{11}
—	—	—	>35KV	>35KV	>35KV	>35KV	>35KV	35KV
—	—	—	4.5	5.4	5.8	5.6	5.0	4.0
—	—	—	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
industrial hydraulics	air-compressor lubrication	turbine and compressor lubricant	plasticizer	plasticizer	capacitor impregnant; heat transfer	heat transfer	capacitor impregnant	transformer dielectric

Czechs Upgrading Brno Fair to Rival Hannover

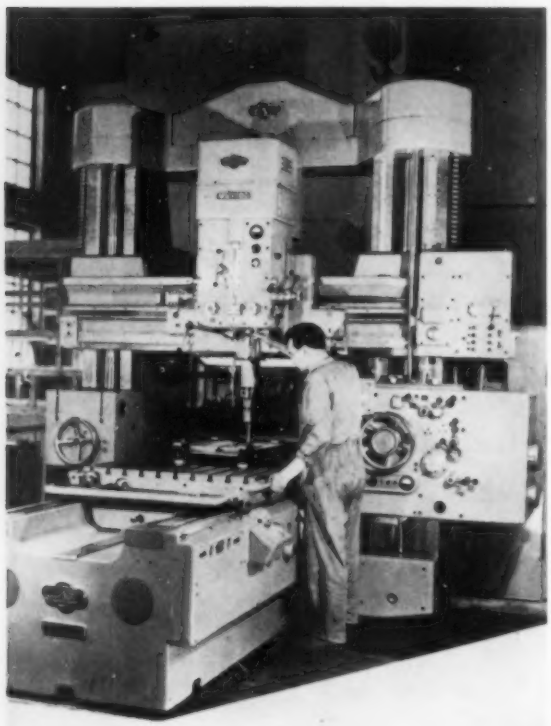
VIENNA—The Czechs are converting their onetime folksy Brno Fair into an international show of machine-tool equipment. With the backing of other Iron Curtain countries they hope this show will steal the thunder from West Germany's Hannover Fair, and make Brno the hub of central and eastern European machine production and sales.

The thinking behind this effort stems from the fact that one-fifth of the annual Czech import-export trade is negotiated at the Brno Fair, where the Czechs did $611-million worth of business in 1959. In addition, 70% of Czechoslovakia's machine-tool production is exported. Trade turnover this year is 13% higher than last.

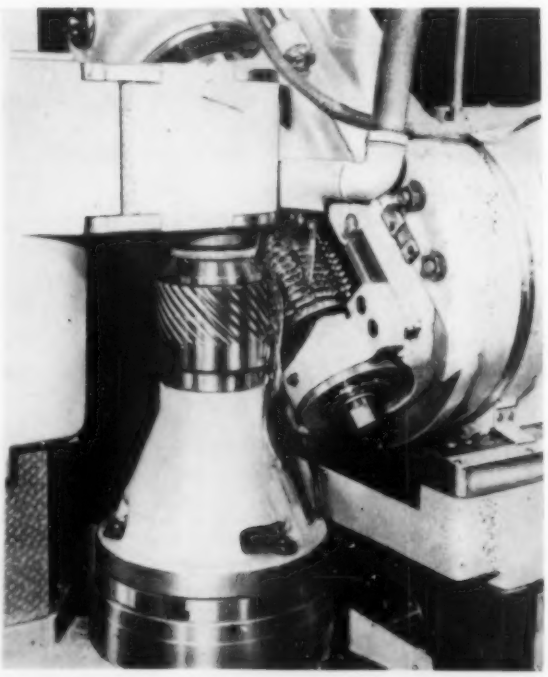
To implement this approach, this year's attendance at the Brno Fair will be somewhat restricted—no more than 1.5 million native Czechs will be admitted, and these must have business reasons for being there—so that some 20,000 foreign customers won't be crowded as they were last year.

As was the case last year, the Soviet Union's exhibits dwarfed those of the other Iron Curtain countries who participated. The 1960 Fair (photos this page) presented 70 machine tools of the top-level production group, 21 of them described as "fully new." The main characteristics of the machine-tool exhibit is the further development of automation, especially of "elastic" automation, which is suitable for middle-series production.

—Fred Baer, McGraw-Hill World News

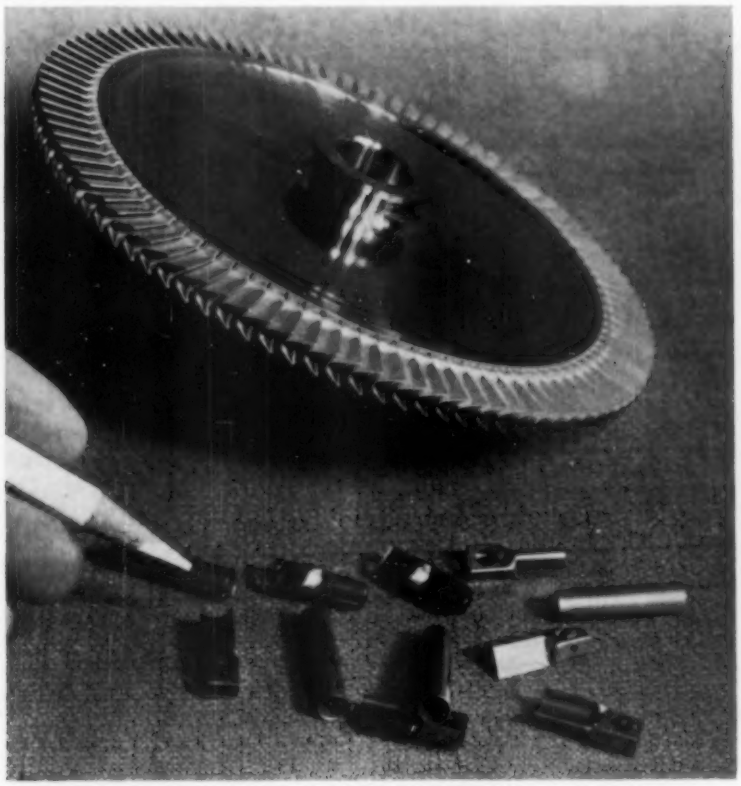


JIG BORER WKV-100 can be used for milling as well as for drilling and boring, and also is said to serve as precision markoff and for parts-inspection. All of these operations can be performed at an accuracy of 1 micron per millimeter. The machine can turn out both male and female threads, metric and Whitworth, and special accessories are not required. The working table (moved hydraulically) is suspended on antifriction bearings; table feeds are infinitely variable from 0.787 in./min. to 13.65 in./min. A special gear is provided for rapid traversing of the table. The vertical headstock, supported by two upright beams, is geared for four-speed pushbutton selection (ranging from 0.984 to 5.90 in./min. while a hand lever provides for the rapid feed at 59.00 in./min. Spindle drive can be shifted through 23 steps ranging from 12.5 to 2000 rpm. A special antifriction bearing was designed for the spindle which can take tools with either metric or Morse taper. The spindle is counterweighted, which simultaneously balances the whole headstock on the guides of the moving cross-rail.



OFP-20 GEAR-HOBBING MACHINE can cut spur gears, helical or worm gears up to 7.87 in. dia. OFP-20 features an electric-hydraulic program-control mechanism for the working cycle. Program control is operated by stop drums said to ensure economic operation even when manufacturing small-number series. Life of the cutter is extended by moving it automatically in axial direction so that the cutting edges are subjected to uniform stress. The unit works semiautomatically—hand loading and clamping is necessary. However, the addition of a supplemental magazine, automatic feeder and a hydraulic clamping device is possible to make the unit usable for transfer lines. A special feature is the high-pressure coolant-jet stream, above, which also removes chips from the tool as well as from the work object. A tank collects the chips while the coolant is discharged through small bottom-located holes. Hob speed ranges from 63 to 400 rpm, feed of the hob slide ranges infinitely from 0.157 to 3.94 in.

Sheetmetal Buckets Cut Weight by 50%



The first practical application of sheetmetal buckets to a turbine wheel cuts weight 50% GE reports. High-temperature nickel-base-alloy buckets permit further weight saving in the turbine wheel itself and in the containment shroud. Low inertia of the rotor simplifies control mechanization. Design calls for operation in temperatures above 1000 F for at least 1000 hrs without maintenance. Buckets are welded to the wheel but other methods of attachment, such as brazing and pinning, can be used to meet varying operating conditions.

Quartet of Ideas Improves Welding

SEATTLE, WASH—Four new approaches to welding, developed by Boeing engineers, allow them to make welded products stronger, cheaper and faster. The new techniques are:

1. **Stainless steel powder,** applied to the upper surface of honeycomb core prior to brazing, improves capillarity, which minimizes draining of brazing alloy from the upper skin to the lower skin. Larger fillets are retained this way to join the core to the upper skin. Fillets are now more uniform because lateral flow of brazing alloy from one honeycomb to another is prevented by controlling the absolute pressure of the brazing retort.

2. **Two new corrugated cores** replace honeycomb in some sandwich-panel applications. Both new types are formed from AM-350 stainless steel material 0.003-in. thick. One configuration has "saw-tooth" corrugations running in a straight line along the sheet. Corrugations are stiffened by a male and female bead pattern. In the other configuration "saw-tooth" corrugations run along the sheet in a sine-wave pattern. The new cores are strong enough to permit welding of the sandwich panels, a technique considered much cheaper than the brazing required on the honeycomb core.

3. **A low-conductivity weld backup** improves quality of aluminum welds. Longer heat retention allows longer out-gassing time with subsequent lower porosity. There is also a 20% increase in travel speed for a given current. Best results are obtained from a backup made of sandwich panels with titanium skins and honeycomb core, but solid titanium backups are recommended for general use, according to Boeing engineers.

4. **Crack-free spot welds** are produced by using a tungsten-inert-gas arc in conjunction with a high-current, short-time-arc spot-welding technique. This has been achieved with PH 15-7 Mo stainless steel, and is believed applicable to other crack-sensitive materials. ■

Senator Wants Blinders Off Federal R & D

WASHINGTON—American companies are finding it increasingly difficult to keep in touch with trends of federal research. This is the conclusion of a US Senate subcommittee, based on a questionnaire circulated among 100 corporations.

Since these companies cannot get adequate information about government-sponsored R & D, they are not making the contributions to technology that they might otherwise, according to the Senate group's chairman, Hubert Humphrey, who issued the report.

He says that more than $7½ billion of taxpayer money is being spent on 100,000 projects in more than 7000 installations, adding "Information generated by these projects is not only vital to national security, but also may play a crucial role in the progress of our civilian economy."

BLAMES FEDERAL AGENCIES

According to Humphrey, the failure of federal agencies to publish indexes of current, nonclassified research work is one of the reasons for poor communications among research contractors. The few existing indexes, he says, are generally out of date and cover only a small portion of existing projects.

The Minnesota Democrat emphasized that publication of current federal research results should not touch on the proprietary work carried out in industrial labs. But taxpayer-financed, nonsecret projects should be made more widely available to prevent duplication of projects and to make government-research dollars more productive. ■

POINTS OF VIEW

THE QUESTION: *What changes do*

VICE PRESIDENT NIXON

SENATOR KENNEDY

For the first time in history voters are being given science, engineering and basic research as campaign issues. True, neither Presidential candidate, Vice President Nixon or Senator Kennedy, is using his R & D thinking as a first-line vote-swinger. But each aspirant has brought science and research to the fore as a part of his tactics.

Nixon made science the subject of his second "Position Paper," preceded only by one on "Communism as a Philosophy." Kennedy has not laid down his views on science as definitively as Nixon, but the Democratic candidate has continually brought up the issue in campaign speeches. When Kennedy hammers at the lag in the US defenses and space programs he calls for more effort, spending and leadership to go into research.

Of the two candidates, only Nixon has laid out a specific program. In his "Position Paper" titled "The Scientific Revolution," the Vice President brought forth a firm proposal that has won wide acclaim in the scientific community. He wants to set up a series of basic research institutes around the nation. They would be somewhat on the order of the famed Institute for Advanced Study at Princeton, where the late Albert Einstein and other scientific giants have had a place to work.

Nixon proposes that the Federal Government match state and industry funds in establishing this network of research stations where scientists could work unfettered by collateral jobs. The centers would be monitored by the National Science Foundation on a federal level, established cooperatively by universities and other research institutions, and governed by boards created by the universities. Their independence would be limited only in that they would not be allowed to usurp any work now being performed by universities.

Nixon doesn't say how many institutions might be desirable, how many scientists might profitably work in them, how much money it might take to get started, or what areas of knowledge should be explored.

Nonetheless, Nixon has scored well with his proposal. NSF officials openly praise the plan. Right now, this foundation spends some $60 million to $70 million a year in support of basic research.

All told, Congress voted some $175 million for the foundation to carry out its research efforts this year. The amount earmarked for basic research forces the foundation to turn down about half of the promising proposals it receives from scientists each year. What the NSF would like to do is support at least two-thirds of the proposals it gets. Unofficial estimates indicate this would cost about $250 million a year.

the presidential candidates want in science and engineering?

THEIR VIEWS ON SPECIFIC ISSUES

While the Vice President's plan for basic-research centers is the only new program offered by either candidate, here are their positions on other related issues, derived from talks with aides, campaign speeches and stands taken in Congress.

Creation of a new department of science and technology with cabinet-level rank:
Neither candidate takes a firm stand one way or the other on this point. Kennedy says he may make a decision on the matter during the campaign. If he goes for the idea, then he will make a strong pitch for the post as a way of strengthening the nation's space and missile programs; if not, nothing will be said. US and Russian achievements in space and missilry in the next few weeks could tilt the decision either way.

Nixon hasn't taken a stand on the matter either. And the speculation is he won't do so during the campaign unless the US receives a severe setback in this field. To do so now would be an admission that the US is lagging in this area.

Providing our allies with more scientific secrets:
Both candidates agree that our ties overseas should be strengthened. Both candidates say that the US growth is geared directly to scientific and technological advances. Each would marshal all possible forces to foster this growth. But neither candidate has offered any specific programs.

Exchanging technical information with the Soviet Union:
Both candidates are taking a hard stand against the Russians. The theme: We must stand up to them. Neither candidate has proposed any further exchange of technical information with the Russians. But, conversely, neither Kennedy nor Nixon says we are doing too much now. Cooperative programs with the Russians carry political overtones of being soft on Communism. It is a point both candidates shy away from.

Applying more American engineering know-how to overseas aid programs:
Specifically, neither candidate singles out more American engineering know-how as a means of improving US aid programs. Both Nixon and Kennedy, however, call for more activity in this area, which undoubtedly would include more engineering services to underdeveloped countries.

Increasing federal aid for the education of more scientists and engineers:
Nixon and Kennedy both favor more federal aid to education, but differ considerably on the amount and the method. Neither candidate singles out scientists or engineers for special treatment, however.

Kennedy backed a bill providing a crash program in school construction—$1 billion a year for two years, with the states providing matching funds—and giving them the option of using the money for teachers' salaries. This is designed to attract support from states which have already had good building programs. He finally was ready to support a bill cutting out the teachers'-salaries option and reducing construction funds to $325 million a year for four years, but it was killed in the House. He favors continuation of the college housing program, with loans to include academic facilities.

Nixon has opposed aid for teachers' salaries on the ground that it opens temptation for Congress to meddle with what is taught and how. He has supported the Administration's debt-financing program for school construction, but recently came out with his own plan, which is more liberal. He wants the Federal Government to service debts by paying the interest on school construction bonds while requiring the local district to pay off the principal. But he would extend this federal aid to debts already existing for past construction. He would also expand federal loans for college housing and classrooms and, like Kennedy, expand the scholarship program. Nixon has made one proposal Kennedy has not—a tax deduction for tuition costs.

Neither has singled out science education or facilities for special consideration, except in the medical field. Both feel that the 1958 National Defense Education Act already gives priority to science.

More spending for research, defense and education:
Without labeling specific increases in any field, both candidates are campaigning on increased federal spending. Programs outlined by Nixon in the Republican platform would increase federal spending by around $1 billion during the first year of the next Presidential term. Kennedy's Democratic platform calls for a higher rate of spending, up to around $5 billion during the first year.

High spending on research, development, education and defense—these are only part of the candidates' over-all programs. But they are sure to get a major share of the extra dollars.

—Seth Payne, *Washington Bureau*

Missile's "Fast Draw" Starts

Cold-drawn Seamless Cuts Clean-up Costs For Anker-Holth's Power Cylinders

The Missile Age version of the "fast draw" starts with the lightning stroke of a power cylinder.

Big, 12-foot stroke hydraulic cylinders provide the power and speed that unsheath one of the nation's principal defense missiles for instantaneous action.

They're made by Anker-Holth Division of The Wellman Engineering Company from Pittsburgh Steel Company's commercial quality, carbon steel, Seamless Mechanical Tubing.

Mounted two to a unit, the husky cylinders must—within seconds, and without fail—slide back the two halves of the hangar-size missile shelter to release the weapon for firing.

Anker-Holth, of Port Huron, Mich., uses Pittsburgh Steel's Seamless Mechanical Tubing to manufacture this critical unit's outer cylinder and piston rod.

Relies on Pittsburgh—What makes this company rely on Pittsburgh Steel for the tubing it requires for this application?

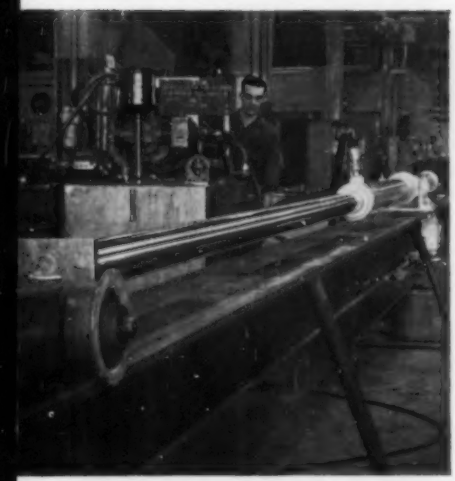
Fred J. Theisen, vice president-production, says there are several reasons. He explains:

"First is Pittsburgh Steel's service. They're able to give us information fast.

"On the first lot of tubing for this job, we asked all our suppliers for recommended sizes for cleanup to our finished dimensions. Pittsburgh

Piston rod made by Anker-Holth for launcher shelter's roof activating cylinder requires only minimum processing for cleanup with commercial quality Pittsburgh Steel Seamless Mechanical Tubing. Finished rods, 142" long, are plated with hard chrome. Vice president-Production Fred J. Theisen, (left) talking with Pittsburgh Steel salesman T. J. Whan, says Anker-Holth relies on Pittsburgh Steel tubing for this missile component.

With Pittsburgh Steel's Tubing



Final hydraulic testing on completed cylinders is comprised of 30 cycles at 4,500 psi—using special Anker-Holth testing equipment.

Fast service, straightness, and minimum stock removal convinced Anker-Holth that "Pittsburgh was best we could get for this job." Cylinder measures 5 inches by 4 inches by 143 inches. Anker-Holth specializes in power cylinders with bores from one to 48 inches, and strokes to 45 feet.

Steel's answer was in first, and it suggested less stock removal.

"That's important, and it's one reason Pittsburgh Steel stays with us. We ask them for size recommendations that we need for cleanup. They tell us the size, and they do it in a hurry. They don't wait around for a couple of months to reply.

"For another thing, when we first started production of this cylinder, we had a problem of straightness.

"I don't know how they did it, but Pittsburgh Steel came through with a batch of tubing I had never seen the equal of. Pittsburgh makes a quality tube. Straightness is the big thing—plus service and the amount of stock we must remove. With Pittsburgh Steel Seamless Tubes we don't need extra metal for honing—so we aren't paying for metal we don't use."

Experience Pays—Close attention to customers' needs and experience, plus steelmaking skills and production practices developed in nearly 50 years of seamless tube production, make Pittsburgh Steel able to serve Anker-Holth this way.

In this instance, Pittsburgh Steel's ability to produce commercial quality cold-drawn seamless mechanical tubing to exacting standards for straightness, concentricity and tolerances, allows Anker-Holth to simplify its cleanup process of the cylinder's ID and centerless grinding of the piston rod's OD.

Machinability and weldability of Pittsburgh Steel's tubing are vital factors in Anker-Holth's production, too, because plugs, ports, sleeves, piston and end covers are threaded and/or welded to the piston rod and cylinder in this application.

Contact one of the distributors or district sales offices listed below. Then let Pittsburgh Steel Company demonstrate its ability and readiness to help. You, too, will find that Pittsburgh Steel's tubing is the best you can get.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California
Chicago Tube & Iron Company
Chicago, Illinois
Cleveland Tool & Supply Co.
Cleveland, Ohio
Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada
Edgcomb Steel Company
Philadelphia, Pennsylvania
Gilmore Steel & Supply Co.
San Francisco, California
Earle M. Jorgensen Co.
Perry Kilsby, Inc.
Los Angeles, California
Mapes & Sprowl Steel Co.
Union, New Jersey
Metal Goods Corporation
St. Louis, Missouri
Miller Steel Company, Inc.
Hillside, New Jersey
A. B. Murray Co., Inc.
Elizabeth, New Jersey
C. A. Russell, Inc.
Houston, Texas
Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois
Solar Steel Corporation
Cleveland, Ohio
Standard Tube Sales Corp.
Brooklyn, New York
Steel Sales Corporation
Chicago, Illinois
Tubular Sales
Detroit, Michigan
Tubular Service Corp.
Springdale, Pennsylvania
Ward Steel Co.
Boston, Massachusetts
Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta Cleveland Detroit Los Angeles Pittsburgh
Chicago Dayton Houston Philadelphia Tulsa
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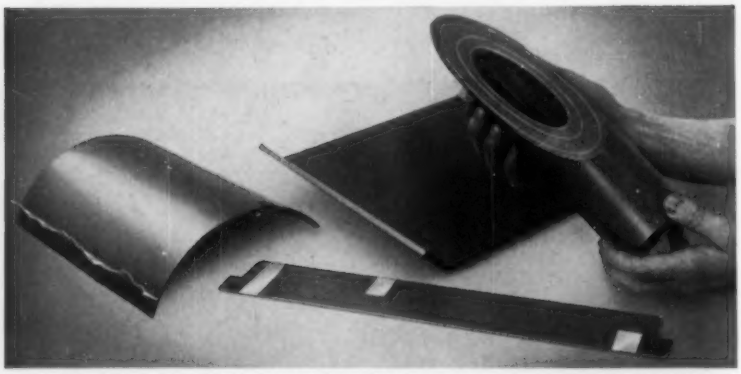
Important facts to know about laminated plastics



A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX paper-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.
- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 39, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

READER TO EDITOR

Which Metric System?

To the Editor:

In your Aug 15 issue, p 44, I read with amazement an article by Prof Carl F. Kayan, entitled "Which Metric System"? If I understand him correctly, he says that we should make two complete changes in our system of measurments, instead of only one, in order to eventually end up with a metric system of units. What is even worse, he claims the Engineering Section of the American Association for the Advancement of Science feels the same way. What these people apparently propose in Operation SCUDS is a decimalization of the foot-pound-second system as a step toward eventually going to the metric system.

I would like to point out that there is no such system as the 'foot-pound-second' system of units. We use nautical miles, statute miles, yards, feet, inches, fractional inches, and decimals of inches for our length units; long tons, short tons, pounds, ounces, and grains for our weight units, where weight here can stand for either mass or force, and of course the additional units of slug and poundal; years, hours, minutes, and seconds are used for time units. In addition, we have probably several hundred specialized units for volume, area, weight, and distance. Since none of these units is obtained from any **other** by decimalization, it will be no easier to decimalize one set of the above units than to switch to the metric system, and it would be a great deal more confusing to both ourselves and the people who use the metric system.

Next, Professor Kayan says there are three competing metric systems and "until the metric world decides on a uniform system it will only invite further confusion for the US to make a sudden shift to any one of these systems." Apparently he thinks that the US, possessing nearly one-half of the entire world's scientific, engineering, and technological know-how, shall sit back timidly and wait for a group of small nations to tell us what metric system to change to. It is preposterous. Our changing to the metric system is primarily for our own benefit. Besides, the metric system we change to will be *the* metric system in a very short time. Also, the meter-kilogram-second system is so clearly superior to all other systems ever devised that I cannot see how there can be any doubt in the minds of intelligent people who have had to perform numerous and extensive engineering calculations.

Another advantage in going to the MKS system is that Russia is already using this system exclusively, and between the two countries we control about three-quarters of the world's technology. It might even help Russo-American relations and it would certainly improve communications between our engineers and scientists.

Finally, Prof Kayan makes the following statements: "A drastic changeover is impossible—the groups concerned would

never be able to agree. But there will never be any progress if we try to push for a revolutionary changeover to the metric system—such a completely new system cannot be introduced overnight."

These are mere excuses, advanced by all opponents to our adopting the metric system, to justify a wholly illogical position. What do these people really mean? Do they mean that they themselves are unable to make the change or that they think the rest of us are incapable of doing so? Other countries made the change with no ill effects; are we to understand that we are less adaptable to new situations than the rest of the world?

Before the change is made, however, we should give serious consideration to changes in our time, angle, and temperature units. Such changes must, of course, be agreed upon by the other major industrial nations before they can really become effective; but I feel certain that the advantages are so great that such an agreement will be reached. The government should be urged to help in this program by appropriating an extra sum of money to the Bureau of Standards for this purpose. During this period all scientific and engineering textbooks and handbooks should also be reworked into the new system so that at the end of the transition period new editions could be put out in which only the new MKS system of units were used. At the end of this period all scientific and engineering papers and books would be required to use the new system of units, and the government would be urged to require all its specifications, drawings and reports to be in the new system. Starting immediately, all schools in the country should be urged to teach the MKS system of units to sufficiently advanced children, and at the end of the transition period the metric system should be the only one taught in our schools. If these things are done, and we start now, I believe that in 10 years hardly anyone will remember the nightmarish system of units we are now saddled with.

—Dr N O Myklestad
Phoenix, Ariz

To the Editor:

The article "Which Metric System?" seems a soundly based, reasonable, and practical approach. Fundamentally, however, it only scratches the surface. The time has come to study the relative merits of a broad system of measurements based on a notation of the powers and roots of ten.

Ten has only two whole-number factors: 2 and 5, which are 20% of the number of units involved. Twelve has four whole-number factors: 2, 3, 4, and 6, which are 33⅓% of the number of units involved and are 66⅔% more factors, proportionately, than 10 has. In a duodecimal notation, 12 would be expressed as 10. Ten could be an italic x. Eleven could be 3 upside down.

A duodecimal notation is more practical. Consider, for an example, the conversion table most commonly used in a drafting room, converting multiples of 1/64 into decimals. Each of the 32-odd multiples of 1/64 requires 6 decimal places for exact conversion. In a duodecimal nota-

continued on page 30

For Trouble-Free, Leak-Proof Connections

ANCHOR FLANCO 4-BOLT SPLIT-FLANGE HALVES AND "O" RING, FLANGED HEAD COUPLINGS

- *Stop Leaks*—"O" Ring gasket gets tighter as pressure increases.
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- *Permit Faster, Easier Connections* — to disconnect, only one bolt need be removed.
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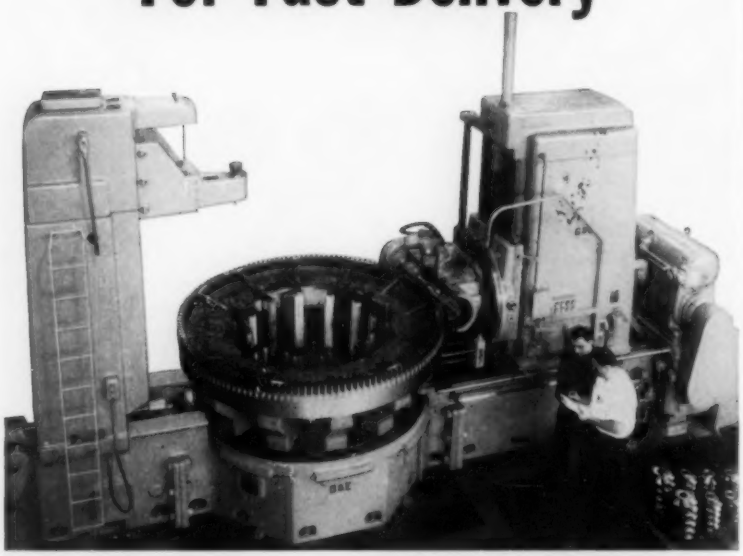

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30 CIRCLE 30 ON READER SERVICE CARD

tion any odd multiple of $\frac{1}{4}$ can be expressed exactly by only 3 digits following duodecimal point—12 cubed is evenly divisible by 64. —JOHN E WHITESIDE
Skaneateles, NY

To the Editor:

Two articles in your Aug 15 issue concerned proposed changes in units of measurement. The extreme difficulty and cost of making such changes shows the importance of arriving at the best possible solution; any changes adopted now would be very difficult to upset if it is later apparent they did not go far enough. Mr McKay (p 46) regrets that the decimal system was not extended to the measurement of time when the metric system was evolved, yet he proposes a halfway measure rather than complete decimalization. If the basic unit of time is the day (and there is little room for arguing the advantages of any other unit), then the logical subdivisons are the deciday (2 hr, 24 min.), the centiday (14 min., 24 sec) and the milliday (one min., 26.4 sec). Then the time elapsed between two events can be expressed in one number, whether it is more or less than one day.

The possibility of reconciling the day with the week, month or year is subject to too much argument for scientific analysis. Astronomers sometimes sidestep this question by giving dates in terms of the Julian Day, which again emphasizes the basic nature of the day as a unit. Similarly angles are better considered in terms of one basic unit—the revolution. As four-syllable words are clumsy, and "rev" already has an accepted meaning, perhaps the words *decivol*, *centivol* and *millivol* could be used.

Mr Kayan's proposal (p 44) is worth consideration. The first step should be to eliminate all units that can readily be dispensed with—the yard, rod, mile, gallon, quart, horsepower, etc. One way to help in this would be to bring educators up to date. Primary- and secondary-school arithmetic still reeks with problems in rods, bushels, pecks, drams, etc., which were archaic when the teachers went to school, and will be forgotten by the students before graduation. The question of whether the foot or the inch will be the eventual unit of length cannot be settled arbitrarily. While civil engineers in general prefer the foot, the machine designer feels the inch is basic; for example g is often given as 386.09 in./sec^2. It must be recognized that an integral number of feet remains integral when converted to inches, while the reverse is not generally true. Perhaps a 10-in. foot is the best compromise.

Simplification of units would come gradually, if every engineer would strive to improve his habits, and not use any system of expressing results that happens to be "customary." —R E HANSEN
Assistant chief engineer
Process & Development Dept
Elliott Co., Jeannette, Penna

To the Editor:

Your special report, p 61, Aug 20 issue, "The European Engineer talks . . ." is outstanding and very interesting. I came

from Germany nine years ago and know the conditions and also the German language, and would like to help promote better technical understanding.

It is my opinion that there must be a way for real international standards to overcome the stumbling block of the metric vs the English system. Would it not be easy to change the temperature measurements from degree F to C within two years and indicate both readings on every scale of new manufactured instruments for this time. I think it would not cost too much, and every engineer would appreciate it.

— O K Grade
Machlett Laboratories Inc
Springdale, Conn

Editors Note:

In answer to several readers inquiries, our Bonn correspondent informs us that a new multi-language technical dictionary will be prepared in Germany by the Central Committee of the Bund Deutsche Industrie. No publication has been announced.

COMING EVENTS

OCTOBER

23-26 . . . . American Gear Manufacturers Assn, Annual Meeting, Edgewater Beach Hotel, Chicago

25-27 . . . . SAE, National Transportation Meeting, Hotel Leamington, Minneapolis

27-28 . . . . American Society of Industrial Designers, Annual Conference, Edgewater Beach Hotel, Chicago

NOVEMBER

2-4 . . . . Society of Automotive Engineers, National Fuels and Lubricants Meeting, Mayo Hotel, Tulsa, Okla.

8-11 . . . . Society of Die Castings Engineers, 1st National Die Casting Exposition & Congress, Detroit Artillery Armory, Detroit

11-12 . . . . American Society for Quality Control, Aircraft and Missile Conference, Lord Baltimore Hotel, Baltimore

14-17 . . . . American Institute of Electrical Engineers, Magnetism & Magnetic Materials Exhibit, Hotel New Yorker, NYC

14-18 . . . . American Society of Tool and Manufacturing Engineers, Western Engineering Conference and Exhibit, Los Angeles Memorial Sports Arena, Los Angeles

16-18 . . . . Porcelain Enamel Institute, 22nd Annual Shop Practice Institute, Univ of Illinois, Urbana

27-Dec 2 . . . . American Society of Mechanical Engineers, Winter Annual Meeting, Statler Hilton Hotel, NYC

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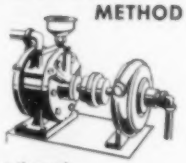
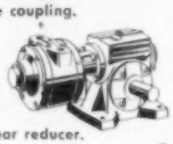


Direct through flexible coupling.



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Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

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H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

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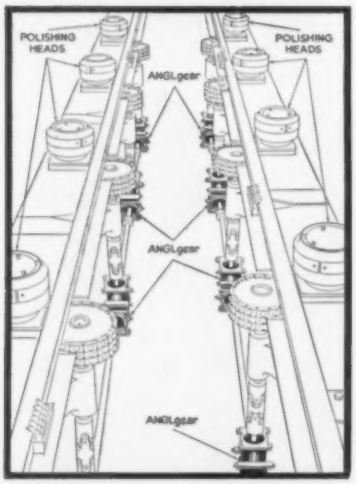

Eight standard model R-350 3-way ANGLgear units are driven by a single motor to transmit power at 90° to indexing heads directly above them and rotate those heads at a constant 60 rpm.

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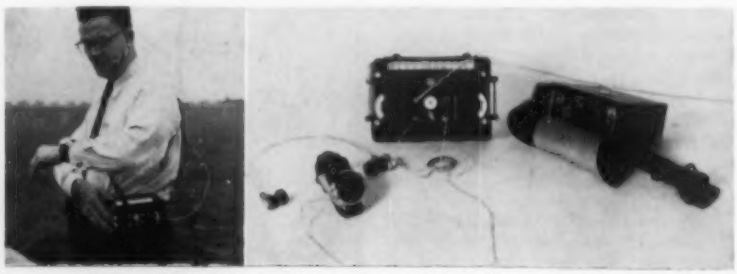
FOR YOUR INFORMATION (personal)

Pocket-size "pointer-outers"

Want to know where you're going—or where that school of fish can be found? The Germans have a "pocket-size" answer to one problem; the Japanese to the other.

The portable, transistorized direction-finder pictured here is Telefunken's latest unit for boating, "marching" and rescue work. It has subminiature tubes as well as transistors, can receive Morse or radiotelephone signals as well as take bearings on transmitters. Frequency range is 57 kcs to 20 mcs, which can be divided into 10 sub-ranges with interchangeable coil cartridges.

For fish-finding, the small Japanese device, made by Japan Radio Co, measures only about 10 by 8 by 8 in., has a barium titanate transducer for sending and receiving signals. An 8mm paper recording spool holds 7 to 10 hours of signals, can use any one of several power supplies, 8, 12, and 24 volts, 52 to 78 watts. Price: about $390.



Personal, Portable Direction Finder can be worn on belt, weighs only about 2½ lb.

Too much fresh oil?

Car oil is changed much too frequently, Hungarian engineers claim. With a simple, portable instrument that measures lube-oil efficiency, they find the "normal" oil-change period is too short at least 70% of the time. About 20% of the changes, based on factory recommendations, are at the right time, and only 10% are delayed too long.

The instrument is basically a color comparator which takes advantage of the fact that coloring of lube oil, as a result of contamination during use, is a valid, if rough, indication of lubrication efficiency. A standard oil sample is spread on one light filter, and the test sample on another. Light transmission through the two filters is then measured and compared with the aid of a galvanometer and potentiometer.

The tests were made by engineers at the Science Research Institute for Motor Vehicles, and are reported in the Hungarian monthly *Ujitok Lapja*.

Power in your palm

With two flashlight batteries, a small motor, and an attractive plastic case about 3 by 4 by 6 in., Thompson Designs Inc, 303 Fifth Ave, New York 16 and Franklin Park, Ill, is producing an array of tools to fascinate the whole family. First out was an electric eraser (*PE—FYI, Nov 3 '58*). Now, the line includes a hobby kit, in which the motor powers a drill, reamer and other tools; and two home manicure sets (one for men and one for women) with disk-shaped grinding wheel, burr, and rubber cuticle-pusher. The diagrams show how they work. The hobby kit is $4.95; the manicure sets, $5.40.

BATTERY-OPERATED "workshop" can be used for drilling (left), routing, sanding, and buffing. Manicure set shapes and trims nails (right).

—ARG

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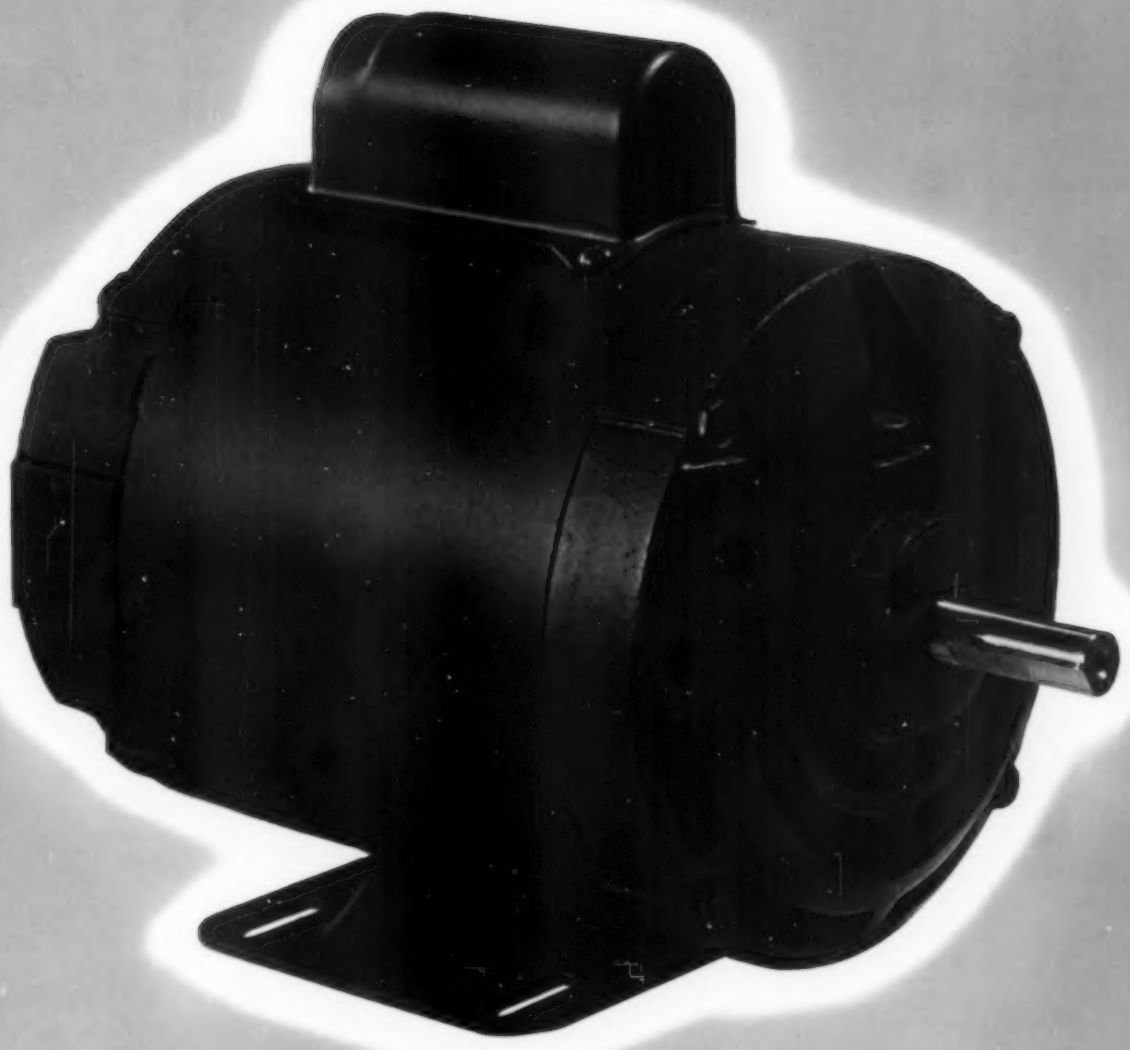
CIRCLE 33 ON READER SERVICE CARD→



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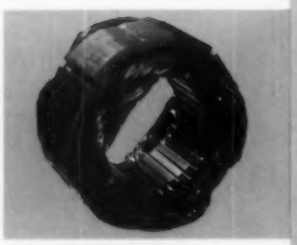
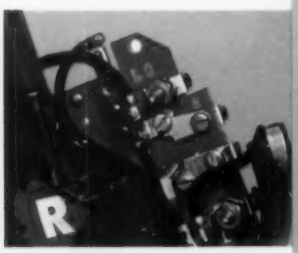
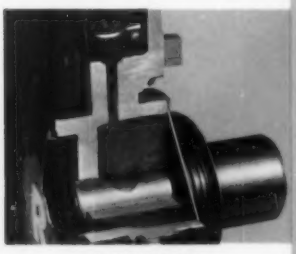


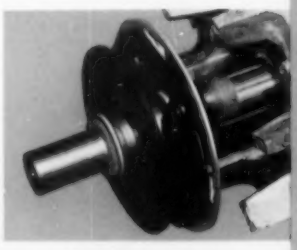
PROTECTED STATOR



TERMINAL BOARD



SLEEVE BEARING



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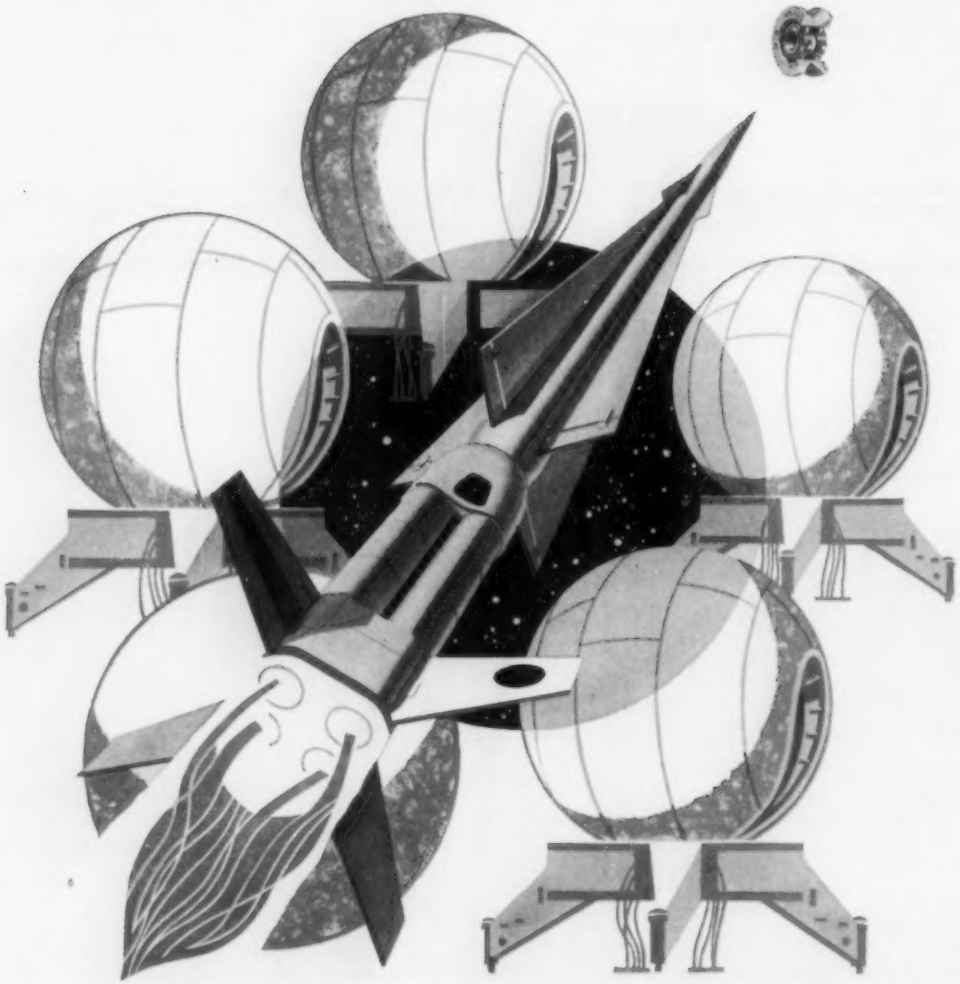

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Helping customers *simplify* instrument assembly is a specialty of the N/D engineering group. How? Through *creative* Miniature/Instrument ball bearing application and design. Often, a new ball bearing design will produce assembly savings in excess of its additional costs. Integral ball bearings, too, very often cut down difficult and costly hand assembly of shaft and parts.

A timely example of N/D customer assembly savings can be seen in Nike Ajax and Hercules missile ground support. Here, *special* N/D Instrument ball bearings are now used in precision potentiometers. New Departure engineers recommended eliminating two *single row* instrument bearings, mounted in duplex and requiring precision spacer and separate guide roller. They replaced this assembly with a *special* N/D *double row* high precision instrument ball bearing with integral outer race guide roller . . . and shaft mounted with a nut. This one recommendation produced cost savings of over 400%! In turn, the customer was able to reduce the potentiometer selling price to the government. What's more, the New Departure Instrument Ball Bearings improved potentiometer reliability!

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MINIATURE & INSTRUMENT BALL BEARINGS

proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

October 24, 1960

HOW TO PERPETUATE A MISTAKE

Each morning, for years, a power engineer set his watch carefully by the chronometer in a jeweler's window, so he was sure he blew the plant whistle on time. Finally, he met the jeweler at an old-timers' festival, and said: "I've always wanted to thank you. For 25 years, I've set my watch by the clock in your window—and it's always right." Said the jeweler: "It ought to be. . . I set it every day by the factory whistle."

Something like that goes on in our current economic research. The economist questionnaires a number of companies, combines and extrapolates the reports—and there are the statistics. His sources see the figures and accept them as gospel. If they were optimistic in their original reports, so is he, and vice versa. And if they do the opposite of their own predictions—as they are currently on capital goods—the figures become wrong. They can talk each other into and out of a boom or a bust. They, in fact, take in their own washing.

The same routine is often followed in engineering. One engineer's basic idea is widely copied. The copyists make superficial changes, but the basic flaws in the original design—if they exist—are perpetuated until some one makes another basic contribution. So we have products that look like peas in a pod, regardless of maker.

Part of the problem is laziness, the willingness to avoid thinking by assuming someone else has done it. Part of it is ignorance. Part of it is awe—a man smart enough to think up the idea must have been smart enough to survey all the possibilities. But I remember the math book of a prominent lecturer, in which most of the simple arithmetic was wrong. Or the expert in atomic math I once hired, who made 17 mistakes in arithmetic in his first expense report.

Basically, an engineer should challenge every idea, every concept and every fact except his wife's age. If this were true in American industry, our cars would not look or act alike, nor would our toasters or vacuum cleaners. And they wouldn't fail in the same ways, regardless of make.

Vance Packard, who brought into the language such phrases as "hidden persuaders" and "status seekers," has in his latest book, "The Waste Makers," attacked the doctrine of planned obsolescence. He criticizes the makers who produce consumer goods with short lives and constant maintenance problems. But he neglects the more serious problem—that our buyers are not discriminating enough to refuse to buy poorly built products. We all buy on faith, a queer reversal of the old Roman adage, "Caveat emptor."

We buy on faith, rather than fact. We like to believe whatever we hear. I remember a friend who once lectured on his solo round-the-world voyage (which he hadn't taken). He said soberly that he hadn't had money enough to buy a good chronometer, so he'd kept six dollar watches in a fruit jar, and took the average for the correct time. Most of his audiences never challenged the statement; they didn't really know that six watches averaged may be no more accurate than one. And they'd have been thrown into hopeless confusion if he had explained that a chronometer doesn't necessarily show the right time either—its accuracy lies in the fact that it errs by a precise, predictable amount.

What is worrisome is that some of the ignorance of the buyers seems to have rubbed off on the engineers responsible for the poorly built products. Either that or the "waste makers" have been most eloquent in convincing their own employees. Or—most threatening—because a man needs a job.

But a buyer doesn't *have* to buy. He may start to think for himself. Perhaps he already is—and that's why the consumer-goods market isn't all it should be.

F. Stangenman

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WHY NOT AC SWITCHES FOR AC CIRCUITS

Most dc switches work for ac too—the reason why few manufacturers have made any changes. But there are some new designs by various companies made specifically for ac; they're smaller, quieter and longer lasting.

RONALD MUNROE, *chief design engineer, Eagle Electric Manufacturing Co Inc, Long Island City, NY*

ABOUT THIS ARTICLE

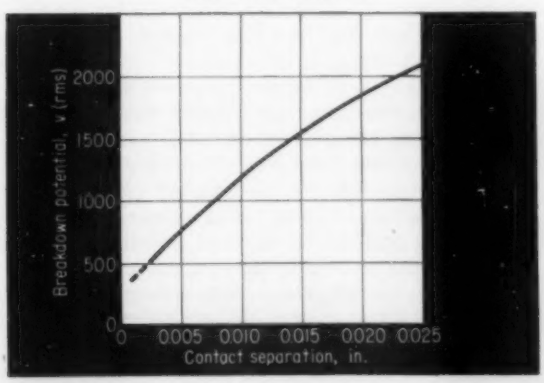
The stimulus for this article was a patented invention by Louis Ludwig, president of Eagle Electric Manufacturing Co. Called "Touch-A-Matic," it is a toggle-action ac switch introduced recently by his company. It led to this question by PRODUCT ENGINEERING editors: "Why the fuss over ac switches when the conventional ac-dc switches are doing the job satisfactorily?" The answer—covering all ac types—is given here by Eagle's chief development engineer, Mr Munroe.

Here is a paradox—though almost all electricity nowadays is ac, 90% of all switches are snap-action, based on old dc-switch designs. Here is why. Originally all power was dc. As ac gradually took over, dc switches—like the common toggle-action wall switch—proved just as good for the new current as well. Therefore, few manufacturers bothered to develop new ones.

But there have been some new designs, and they are superior for use with ac. They are slower opening than the dc types, and take advantage of the fact that, with ac, current flow stops each half-cycle. Before the contacts have a chance to move far apart, voltage reverses and breaks the arc. This prevents the arc from elongating and possibly spreading out. The arc breaks readily, even though these ac switches have much smaller contact separation—0.020-in. vs. 0.5-in. gap for typical dc snap-action type. And since the contacts are closer, these switches can be made much smaller than dc ones.

At first, standards were written only for the older dc types, but now Underwriters' standards for ac switches cover most applications; and most dc switches are rated for ac use as well.

ARC-OVER VOLTAGE



AC SWITCH is likely to arc if designed with contact gap less than plotted values.

COST IS MAIN LIMITATION

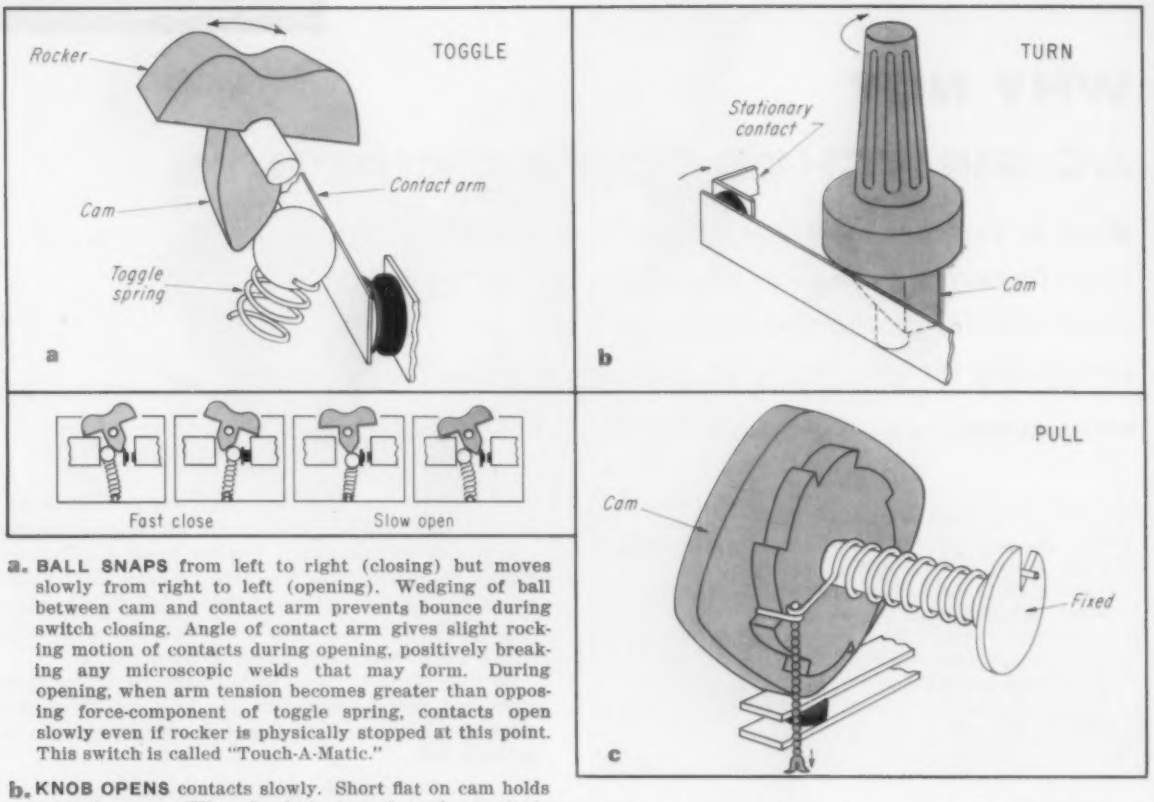
What has slowed down adoption of ac switching in our predominantly ac country? Cost, mainly. Manufacturers would have to retool for new designs and develop low-cost, mass-production techniques. There are other drawbacks: Underwriters' standards were only recently revised to allow testing on ac instead of dc; the user needs education in new concepts; and a very minor limitation—the slower, smaller ac switches will not work on dc.

DRAWBACKS OF DC SWITCHES

Dc switches are designed to allow for the fact that dc gives you a continuous arc—with no voltage reversal to stop current flow. They must open rapidly with wide contact separation to elongate and break the continuous (dc) arc before it has time to damage the contact surfaces. Closing is rapid too, to shorten total time of arcing. The trouble with drawn-out arcs is that they accelerate carbonization (tracking) of molded parts, which leads to switch failure.

Strong springs and other high-force mechanisms are needed to give fast action, and actuating forces are high. These switches are larger than ac types because of wider contact separation, and noise level is higher. Contacts move farther and hit harder, and the larger mechanism has higher friction and stresses—increasing noise and reducing life.

Contact bounce can occur when switch closes at high velocity, causing an electrical arc on each bounce. This becomes a serious problem with tungsten-filament and other filament-type loads, because surge current in a cold filament is about ten times the normal hot-filament



a. **BALL SNAPS** from left to right (closing) but moves slowly from right to left (opening). Wedging of ball between cam and contact arm prevents bounce during switch closing. Angle of contact arm gives slight rocking motion of contacts during opening, positively breaking any microscopic welds that may form. During opening, when arm tension becomes greater than opposing force-component of toggle spring, contacts open slowly even if rocker is physically stopped at this point. This switch is called "Touch-A-Matic."

b. **KNOB OPENS** contacts slowly. Short flat on cam holds contacts open. When knob is turned again, contacts close rapidly because tension on contact arm throws cam around (providing knob is not held back by the operator).

c. **CHAIN ROTATES** cam to open contacts slowly. Closing is faster because tension of contact arm throws cam to flat position independent of chain.

d. **CONTACTS CLOSE SLOWLY,** depending on operator's speed. Contacts are opened slowly in same way.

e. **PRESSING BUTTON** breaks contacts slowly. When spring raises button to top position, vertical arm relocates from narrow slot to the V groove in button. When button is depressed again, vertical arm is moved to left by the V, releasing the movable contact arm. Contacts close rapidly. This switch was invented by the author.

f. **ROTATION OF MERCURY** capsule moves liquid, connecting the terminals.

g. **CURRENT** through resistance windings heats thermal blade, causing contacts to close (or open) slowly.

current. One way bounce can be controlled is by having a sliding action at the contact surfaces, but this causes friction and wear. Sliding helps lower contact resistance, however.

HOW THE AC SWITCHES WORK

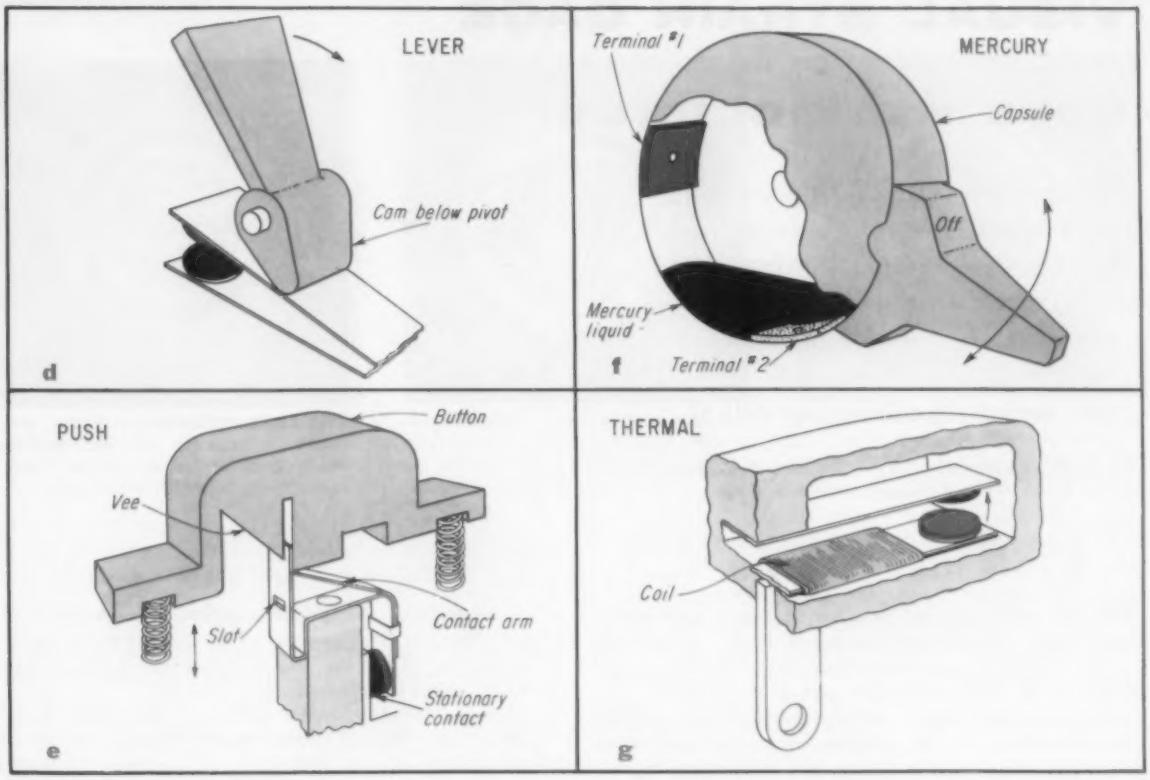
Ac switches can have small contact gap, and speed of opening can be slow, because arc is extinguished automatically when voltage goes through zero point of cycle. About 0.005-in. gap (depending on contact surface and atmospheric conditions) is enough to prevent an arc from restriking up to 300 v. Arcs up to 0.010 in. long are not troublesome because there is very little spreading out—which would damage adjacent parts—in such a short length. Longer arcs—0.020 in. and over—could cause damage, depending on switch design.

Proper break velocity to give desired arc length can be designed into the switch. If this correct velocity can be constantly maintained, arc length can be even less than 0.005 in. Correct velocity is anywhere from 0.6 to 3.6 in./sec, figured this way: time of travel should be from ½ to ¼ cycle (1/120 to 1/240 sec) over distance (gap) of from 0.005 to 0.015 in. See chart on previous page.

Forces in ac switches can be low, because heavy springs and mechanisms are not needed. Both dc and ac switches can be actuated by throwing a lever, pushing a button, turning a knob or stroking a rocker, but the ac type takes less force and is quieter.

There is less contact bounce in ac switches than in dc on closing because movement is slower. However, closing is usually designed to be faster than opening, because once the arc strikes, there is no need to prolong the time of travel. Arcing that lasts too long will increase melting of contact surfaces, causing pitting, material transfer at contacts, and possibly serious welds. What is needed is the highest closing velocity without bounce.

Silver-alloy contacts rather than conventional copper ones are used for ac switches. Silver's higher conductivity inhibits pitting and welding, gives longer life. More important, the oxide that forms conducts current even when contact pressure is low, despite lack of "wiping" action to break through oxide film. Dc switches can have



copper contacts because higher pressures are possible to give heavy wiping action that breaks through oxide.

TYPICAL AC SWITCHES

Sketches on these two pages show several designs—made by various manufacturers—suitable for ac switching. All are slow-opening but they differ in other details.

Cam-type ac switches are available in two styles: cam-actuated *opening* and cam-actuated *closing*. The first has contacts normally held closed by contact-arm tension, and the cam action forces them apart. Second style is the reverse: its spring force holds contacts open, cam closes them. For both, the cam directly controls speed and position of contacts, and operator must be careful to move actuator at normal speed and not restrict full stroke. Otherwise he may hold contacts open at some critical separation distance long enough to cause excessive arcing.

With cam-actuated-closing ac switch, opening force exerted by contact arm must be great enough to break contacts loose if minor welding is inherent. For this reason, most cam-actuated switches are cam-opened.

Ac toggle-action switch differs from cam-type in that closing motion is snap action, triggered when ball element rides over point of toggle. And unlike the cam switch, opening cannot be stalled by a careless operator. Any normal speed of manual operation will open contacts well within max and min velocity limits. Life of the ac toggle switch can be four times that of an equivalent dc switch operated on ac or dc—about 100,000 cycles vs 25,000 cycles for ordinary 20-amp ratings.

Silver-alloy contact surfaces do not overheat during opening, even though contact pressures drop to practically zero. This is because contact resistance stays low and constant at the relatively low pressures exerted by ac switches. Pressure is not a factor with silver contacts unless it is high enough to cause metal flow, thus increasing effective contact area.

High potentials—up to 2500 v—can be withstood by ac switches with contact separation of only 0.03 in. Toggle movement can therefore be relatively small.

Mercury switches have long life and quiet operation, thanks to sealed-in liquid. These switches open and close slowly in response to operator's touch. Surface tension of mercury also affects response but liquid contact is perfect regardless of variations in speed. Electric arcs that would cause damage in ordinary metal contacts do not hurt mercury. However, the condensed mercury vapor that results will reduce contact separation over surface.

Mercury switches are larger than cam or toggle ac switches because considerable liquid is needed to ensure positive closing and sufficient contact separation.

EDITOR'S NOTE: A good background on dc and ac switching is provided by these previous articles:

Snap-action Switches, Apr 13 '59, p 58—Compares performance of miniature and heavy-duty ac-dc switches, and gives details of mechanical and electrical behavior.

Electro-ionic Device, July 27 '59, p 38—Describes invention of switch that conducts full-wave ac through a special electrolyte instead of via contacts. Electrolyte can be made conducting or nonconducting instantly with a small electrical signal.

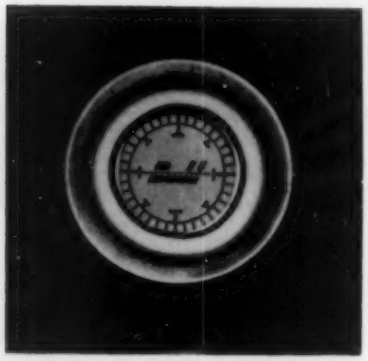
VISUAL STRAIN GAGE

does work of three

Equipped with a built-in polarizer, the photoelastic rosette separates and measures the principal strains—giving direct readout of fringe displacement. Here's how the new PhotoStress gage works, and equations needed for calculating with it.

DR FELIX ZANDMAN, *director of research & development*
Instruments Div, The Budd Company, Phoenixville, Penna

FRINGE PATTERNS OF



(1) ZERO STRAIN condition with frozen fringes in original position ready for measurement. Pictures were taken with monochromatic light.

Shown below are the elements of a new photoelastic strain gage designed to measure—without a polariscope—the magnitude and direction of the separate principal strains at the point where the gage is attached.

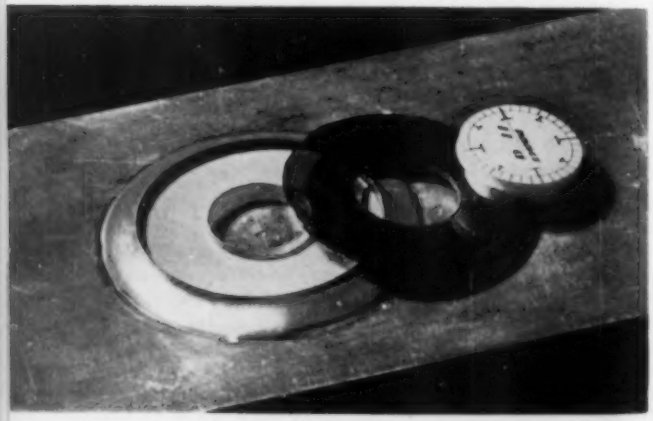
The new strain gage is called a rosette because it does the same job as a rosette pattern of three resistance strain gages. It consists of three parts: (1) A photoelastic disk with a center hole into which permanent strains have been "frozen"—thus it exhibits a permanent fringe pattern. This strain pattern has circular symmetry, so that the fringes appears as colored circles in white light. (2) A circular polarizer, carried on top of the photoelastic disk by a centering button that fits into the hole. (3) A circular scale cemented over the centering button to measure directions of principal strain. Aluminum paint is applied to the bottom surface to improve reflectivity.

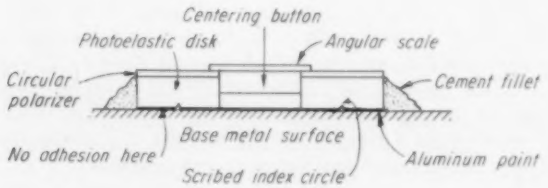
How It Works

The gage is bonded to the structure's surface with a strong cement, but the bonding is done only along the outer edge of the gage. No cement is applied to the bottom surface. When load is applied to the metal structure, strains in the gage area are transmitted to the photoelastic disk. Thus the disk performs like a photoelastic model subject to edge-loading.

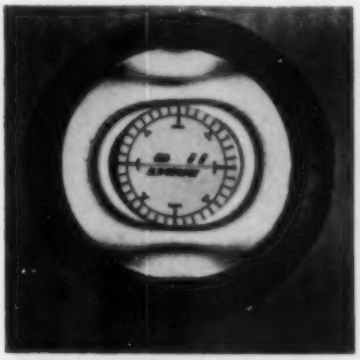
Because the disk already contains a permanent fringe pattern, the external strains applied displace or distort the existing circular pattern into an ellipse or similar figure (an isotropic applied-strain system will retain circular fringe symmetry, but expand the pattern radially). The axes of symmetry of this figure correspond to the principal strain directions. The fringe displacement along a given principal axis is directly proportional to the principal strain along the axis perpendicular to it. This is because the disk has been proportioned so that pattern displacement along one principal axis is independent of strain along the other.

The measurement that gives magnitude of principal strains is therefore reduced to the measurement of photoelastic fringe displacement in the gage. Multiplying this displacement by the constant of the gage (see p 44 for calculation method) gives the strain in microin/in. A

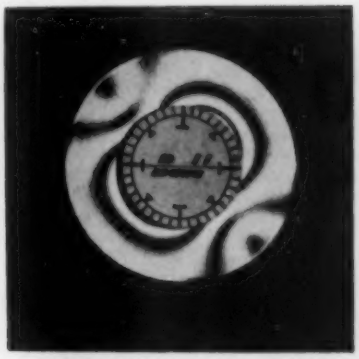




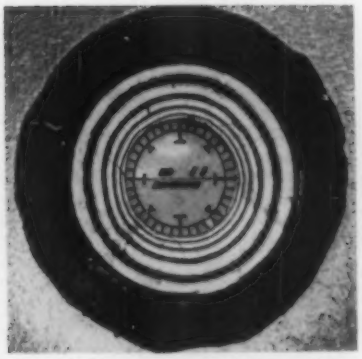
PHOTOSTRESS ROSETTE IS A DISK made from photoelastic material cemented to the base metal surface around its outer periphery only. Circular polarizer, riding on top, is made from a linear polarizer and a quarter-wave plate sandwiched between two layers of acrylic sheet. Angular scale pasted on top allows measuring the direction of principal strain. Scribed circle on back of gage indicates position of index fringe at zero strain.



(2) **PURE TENSION,** hence ratio of principal strains equals —1/3 (principal axes correspond to axes of symmetry of fringe pattern).



(3) **TORSION,** hence ratio of principal strains equals —1 (principal axes at 45° with respect to axes of specimen). Built-in scale measures angle.



(4) **ISOTROPIC LOADING** condition such as hydrostatic compression or uniform thermal expansion (note symmetry; all axes are principal axes).

magnifying glass containing a linear scale will facilitate accurate measurement of fringe displacement.

Major Features

In addition to indicating separate principal strains and their directions, the photoelastic rosette has the following features:

Accuracy in routine analysis is ±5° for directions of principal strain, and ±40 microin/in. for the magnitudes of the separate strains. Influence of one principal strain on the other (lateral sensitivity) is less than 2%.

Readout is direct and sensitive. No interpretation of pattern is necessary, since only distortion of permanent circular fringes is being measured. Strain directions can be measured at strain levels as low as 50 microin/in.

Readout has constant sensitivity for directions and magnitudes regardless of strain level. This is because of the existence of the initial fringe pattern—frozen into the gage. Both sensitivity and zero location of the index fringe are stable with time and humidity.

Maximum strain possible without exceeding the linear optical limit of the gage material is approximately 20,000 microin/in. Monochromatic light must be used for these very high strains because under white light too many colored fringes will blend in the gage, preventing accurate measurement. Rosettes can be made with lower sensitivity photoelastic materials so that high strains will produce only 3 or 4 fringes.

Readings of dynamic strains are possible, since the gage output is visual. For cyclic dynamic strains, a strobe light is used.

These Limitations

There are several limitations on the photoelectric rosette, some of which stem from the optical basis of the system:

Light is required so that the fringes may be observed. Any light will suffice, but this need for illumination prevents analysis in enclosed locations as is possible with resistance strain gages.

Accuracy is low in regions of high strain gradient. This is because the gage is fairly large, 1¼ in. dia. When a strain gradient is applied, the gage will only give an average value. In addition, if the strain directions vary within the rosette area, an irregular distortion of the pattern is observed. In such cases, PhotoStress coating technique should be used. Smaller rosettes are possible, but are less sensitive because thickness must be reduced to maintain lateral sensitivity less than 2%.

Accuracy of the gage is not as good as the accuracy of the PhotoStress coating technique which, on strain magnitude, is good to ±10 microin/in.

Temperature limit on accurate performance of the gage is about 140 F. Above this temperature, the gage begins to lose its locked-in fringes. Above 110 F, gage-sensitivity corrections must be made because the PhotoStress material displays a lower fringe displacement per unit of strain applied. For temperatures up to 110 F, the original gage factor supplied with the gage applies. A correction, however, must be made for the shift in position of the permanent fringe pattern due to isotropic thermal strain. This zero shift is symmetrical, and amounts to a fixed amount of fringe movement per degree F change in temperature. To avoid this correction, the gage can be bonded at operating temperature. A dummy gage also can be used for correction.

Gage Installation

The PhotoStress gage is ready to install as-received. The surface to which it is applied should be cleaned of grease and scale with any normal solvent. A reflective metal surface is not necessary. The gage itself should not be cleaned with solvents.

Simplest way to apply the gage is to attach it to a predetermined area with a strip of cellophane tape, then form a heavy fillet of adhesive around the outer edge. Adhesive should not be allowed to slip underneath the gage. This is a problem on vertical surfaces. Here, a disk of masking tape having double-adhesive surfaces can be installed on the metal surface. The gage is then pressed onto the tape and the cement applied around the edge. The masking

CALCULATING THE PRINCIPAL STRAINS

The diagram at right shows what happens to the "frozen" fringe pattern when the PhotoStress rosette is strained by the stress field in the metal beneath it. The index fringe is taken as the junction between red and blue, called tint of passage, the easiest point to follow under white light. Under monochromatic light this junction line appears as an intense black fringe, and is sketched at right to avoid color problems.

Calculation of the principal strains is based on the fact that fringe movement in a photoelastic material occurs only as a result of strain change. When the photoelastic model has a constant thickness, then the relation between fringe movement and strain is linear if the frozen pattern has a linear radial-fringe gradient. The slope of this "calibration" curve is material constant b, in microinches per in./in. of movement—as shown at lower left in sketch.

By moving this curve to the right so that its origin coincides with the inner radius of the rosette, the equation for calculating e_n is easily constructed.

At zero applied stress, the strain in the rosette is e_i, represented by the circular frozen fringe at r_i. Strain e_i is not given, but does not need to be. As a medium stress is applied, the frozen fringe distorts to radius r_m. Since the rosette is designed so that strain along axis 1 is independent of strain along axis 2, the applied principal strain is calculated.

$$e_2 = e_m - e_i = b(r_m - r_i)$$

Since diameter distortion is easier to measure than radius distortion, a factor of 2 is introduced so that $B = b/2$; then

$$e_2 = B(d_m - d_i)$$

Constant B is termed the rosette gage factor, and is supplied with the rosette.

A complication arises as higher stresses are imposed. Fringe 1 distorts so much that its extremity in the direction of e_1 nears the edge of the gage r_d and passes beyond it to some imaginary radius r_h. If the rosette were bigger, the fringe would show as the dashed line; however, the fragments do not intersect axis 1.

Fortunately, a second fringe (representing a higher intensity of strain) appears at the inner radius of the gage r_n, before the frozen fringe disappears at the outer radius r_d. Fringe 2 then replaces fringe 1 as the measuring or "index" fringe. The actual strain becomes the strain e_n calculated from movement of fringe 2 plus a constant representing the strain necessary to make fringe 2 assume the initial position of fringe 1. This constant c is the interfringe value, and is given by

$$c = b(r_i - r_i')$$

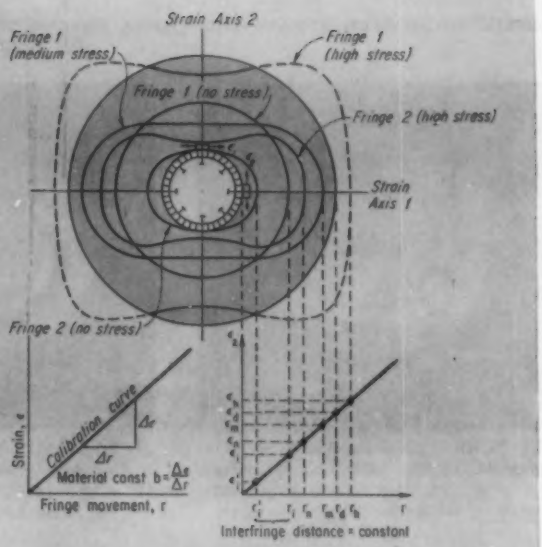
The applied strain is thus $e_n + c$, or

$$e_2 = b(r_n - r_i) + b(r_i - r_i')$$

Converting to diameter measure

$$e_2 = B(d_n - d_i) + B(d_i - d_i') \qquad (5)$$

In summary, the principal strains can be calculated



from the diametral movement of the index fringe using these two simple equations:

$$e_1 = B(\text{movement along strain axis 2}) + c$$
$$e_2 = B(\text{movement along strain axis 1}) + c$$

Constant c is supplied with the rosette (about 700 microin/in.) and is used only when the index fringe becomes fringe 2 because fringe 1 has disappeared along the axis of measurement. Sign of the strain is plus (tension) if the index fringe moves outward, negative (compression) if it moves inward.

Note that the PhotoStress gage can be designed so that fringe movement is not directly proportional to strain applied. Here, a calibration curve is used.

SYMBOLS

- r_i — Initial radius of permanent circular fringe pattern, fringe 1, before gage is stressed.
- r_i' — Initial radius of permanent fringe 2, before gage is stressed.
- r_m — Radius to fringe 1 along strain axis 1 after a medium stress is applied.
- r_d — Radius to fringe 1 along axis 1 as the fringe disappears from the gage at the outer edge after more stress is applied (r_d = outer gage radius).
- r_h — Radius to fringe 1 along axis 1 after a high stress is applied (fringe 1 is actually cut off by boundary of gage).
- r_n — New radius to fringe 2 along axis 1 after fringe 1 reaches its imaginary radius r_h.
- e_i — Initial strain frozen into the rosette, represented by the initial fringe pattern at r_i.
- e_m — Total strain in gage along axis 2 after medium stress is applied.
- e_h — Total strain in gage along axis 2 as high stress is applied, and as fringe 2 moves to new radius r_n.
- e_1 — Applied strain along axis 1
- e_2 — Applied strain along axis 2

tape isn't adhesive enough to interfere with gage.

Two types of adhesive have been used successfully: epoxies and contact cements. Budd Instruments Division's type RCT is an epoxy cement that fully cures in 24 hours at room temperature, with no pressure needed on the gage. A full fillet should be used with RCT. Eastman Kodak's 910 is a contact cement that cures in 60 seconds under light finger pressure at room temperature. Since 910 cement is more fluid than the epoxies, only a small corner fillet should be applied to prevent bonding of the complete gage interface. Cement 910 is more brittle, so maximum strain level must be reduced to 5000 microin/in.

HISTORICAL NOTE

The concept of using a hollow photoelastic disk, bonded only about its outer edge, for resolution of principal strain magnitudes and directions was developed by the late Dr Georges Golubovic in France prior to 1956. The Golubovic device, however, required auxiliary instrumentation for precision measurements. The PhotoStress adaptation of the Golubovic device adds a frozen fringe index pattern and allows precise measurements to be made directly without additional instrumentation.

THESE FLUIDS
for 500 F and above

Many of them are still labeled "exotic." But some are already at work in machine tools and aircraft hydraulic systems, and others are being readied for tougher specifications to come. Here are the major types and what they offer.

ANNESTA R GARDNER
Associate editor

Furnaces cooled by liquid metals . . . hydraulic systems needing oils that stand 800 F and more . . . heat-transfer units operating on molten salts . . . these are not dreams (or design nightmares) of the future. They are drawing-board realities of today because increased efficiency so often requires increased operating temperatures.

For 400 F and below, it is possible to get plenty of military-approved petroleum oils and synthetic organics. And in closed systems, several of the conventional fluids, though not rated for service above 500 F, can nevertheless serve quite satisfactorily at 500 F or even a bit higher. Their flash points range from 350 to 450 F; but when protected from air, they are well able to stand the higher temperatures. Examples of such fluids are California Research Corp's radiation-resistant fluids, Sun's heat-transfer oils, Carbide's Ucon fluids and silicates and Esso's new Humbletherm 500. Monsanto's Santowax R is another. Its flash point is a mere 375 F; but tests at North American Aviation show it can be successfully used in closed systems at temperatures at least to 800 F. It's one of the primary coolants for North American Aviation's organic-moderated nuclear reactors. Likewise, many of the fire-resistant hydraulic fluids, like Mobil's Pyrogards, and Monsanto's Skydrols, may prove useful at temperatures well above those for which they were specifically designed, since they have no true flash point and their self-ignition points are well above 900 F.

But in open systems, or at temperatures in the 800-F to 1500-F range, new materials and new design approaches are needed—and are being found.

Old materials—new jobs

Some of these "new" materials are actually familiar compounds—such as the molten salts, long used in heat treatment. But they're being put to work in new ways now. Water, too, is a "new" heat-transfer medium—and so are many of the liquid metals.

At first thought, it might seem that such fluids would pose nearly insuperable problems of heating, lubrication and corrosion. Actually, that is not the case. Some molten salts are considerably less corrosive to a steel than ordinary water; and some molten metals are pretty good lubricants.

Bearings are being operated on liquid mercury, for instance, at speeds in excess of 40,000 rpm. Tests of

CHEMISTRY AND FLUIDS

Chemical combinations of carbon, hydrogen, chlorine and fluorine form the basis for the new high-temperature organic fluids described in this report. Their names are long and their structures complex, but most of them fall into the general categories of phenyl ethers, esters and diesters. Here, basically is what these terms indicate:

Phenyl means simply that the basic structure includes one or more C_6H_5 groups—the familiar hexagonal benzene rings. Thus "chlorobenzene" (C_6H_5Cl) is also known as "phenyl chloride"; and the polyphenyl ethers are literally ethers containing many phenyl groups.

An ester, the organic counterpart of a salt, results from an organic acid reacting with an alcohol. (A salt is product of interaction between an acid and an alkali.)

An ether is any organic compound in which two groups of atoms known as "radicals" are joined by an oyxgen atom, like this: C_6H_5-O-C_6H_5.

A diester is an organic compound in which two ester groups are joined to the central chain structure or ring.

a carbide cylinder rotating between paired V-blocks with a sodium-potassium alloy as the lubricant showed coefficients of sliding friction ranging from 0.13 to 0.23 at bearing loads of 1000 to 1700 psi. And the fact that molten salts are successful as metal-drawing compounds indicates that they, too, have considerable lubricating ability. The liquid metals also offer high thermal conductivity and high bulk modulus. One "packaged" sodium-potassium cooling system, for instance, designed by MSA Research Corp for copper crucibles of vacuum melting furnaces, will handle a heat load of 500,000 btu/hr.

Another big advantage of the salts and metals: In general, they're considerably cheaper and more available than the exotic chemical compounds serviceable at 500 F and above. Furthermore, many of the salts and metals are adaptable to electrical pumping systems far simpler than the pumps ordinarily used for oils.

Comparison with organics

Still, none of the major types of fluids available for high-temperature service should be neglected when new designs are under consideration. Each material has its own advantages and limitations.

The fluids available for service at 500 F and above today fall into three major categories: organic compounds, liquid metals and inorganic salts. Pressurized water and such nonmetallic elements as sulfur are also used (see chart), but these are special cases.

In general, the organics offer fluidity at room temperature, low corrosivity, and a fair degree of lubricity. But they do have a top operating limit well below that of the other materials; they may decompose even below their top limit under certain conditions; and they may cause corrosion even though they are not themselves directly corrosive. The breakdown products formed by thermal degradation of these compounds may attack metals directly, or they may promote corrosion by preventing free flow of materials and by causing an uneven sludge buildup that will create local hotspots.

How liquid metals rate

The liquid metals and molten salts, on the other hand (aside from mercury and the sodium-potassium eutectic), are solids at room temperature and may pose severe sealing problems.

Engineers who have been working with liquid sodium—at Knolls Atomic Power Laboratory, Babcock & Wilcox, Alco Products, and other laboratories—stress that sodium will burn in oxygen at high temperatures and will react violently with water when oxygen is present. Equipment must, therefore, be leaktight. Furthermore, the rapid thermal transients which may occur in improperly operated systems can cause extreme material stresses. Other liquid metals may pose problems in diffusion bonding and mass transfer; and some, like mercury, are toxic.

Still, mercury has plenty of industrial uses which get around these problems; and sodium-cooled valves have been used in truck engines for years without undue problems. Also, the liquid metals have a number of advantages. There is no top operating temperature, they are adaptable to simple and effective magnetic pumping systems, and they are actually less corrosive to some common materials than are the organics or water. Too, they have the high thermal conductivity and high bulk modulus that are desirable in many cases.

HI-TEMP FLUIDS—*Liquid Metals and Molten Salts*

Material	Bismuth	Lead	Mercury	Potassium	Sodium	Sodium-Potassium Eutectic	Sodium-Potassium Nitrate-Nitrite Mixtures	Sulfur	Water (1500 psig)
Melting Point, °F	520	621	−38	147	208	12	290	234	—
Normal Operating Temp. Range, °F	600 to 2000	700 to 2000	0 to 1000	200 to 1200	250 to 1500	100 to 1400	300 to 1000	260 to 800	500 to 600
Boiling Point, °F	2690	3160	675	1400	1620	1440	—	832	596
Specific Heat, btu/lb/°F	0.36	0.37	0.33	0.18	0.32	0.21	0.4	0.2	1.0
Volume Change on Fusion (% of Sol. Vol.)	−3.3	+3.6	+3.6	+2.4	+2.5	+2.5	+10 to 50	+10	—
Absolute Viscosity (centipoises)									
500 to 700 F	1.1	1.6	0.6	0.2	0.3	0.2	2.0	1116 to 178	0.1
1300 to 1400 F	0.5	0.9	—	0.14	0.1	0.1	0.5	—	—
Specific Gravity	10	10.2	12.8	0.75	0.9	1.9	1.8	1.8	1.0
Thermal Conductivity btu/hr/ft/°F	6	8	7	26	47	15	58	0.1	0.33
Price ($/lb)	2.25	0.12	2.80	2.25	0.20	2.00	0.13	0.01	—
Representative suppliers	Asarco Anaconda Cerro	Asarco Eagle-Picher Intl. Smelting	J T Baker F W Berk Mallinckrodt	MSA	DuPont Ethyl Natl. Distillers	MSA	E F Houghton DuPont	Texas Gulf Freeport	—

These are the best organics

The organic fluids showing most promise for high-temperature development are, in general, those hydrocarbons which contain fluorine, chlorine, or silicon. They are complex materials, differing not only in composition, but also in structure. Some are basically alcohols, some are esters, and some are ethers (see "Chemistry and Fluids," p 45). To the engineers, the exact composition is unimportant. It would even be helpful if the chemical names could be ignored entirely—particularly since one group of compounds frequently has several different names in the literature. For instance, the phenyl methyl siloxanes are frequently called "silicones," and the polyphenyl ethers are also frequently called "phenoxy phenyls."

Where to get help

The variety and complexity of these compounds make it especially important for the engineer to work closely with suppliers in choosing fluids for high-temperature service, and organic producers offer a good deal of help.

Suppliers are less helpful when it comes to molten salts and liquid metals. This is primarily because the materials themselves are old and cheap, and these applications do not bulk large in the marketing picture. Suppliers have data on density, melting point, and the like; but are not nearly so active in exploring and promoting heat-transfer and hydraulic applications as are the suppliers of organic compounds. There are a few notable exceptions. MSA Research Corp, for instance, offers much help on those it supplies, and even publishes a quarterly *Liquid Metals Technology Bulletin*, available on request to its Documents Control Div.

For the most part, though, on liquid metals and molten salts the best sources of information are government publications prepared by the Atomic Energy Commission and other agencies. Lists of these may be obtained (for 10¢ each) from OTS, Dept of Commerce, Washington 25, DC. There are three lists: *Alkali Metals* (SB 421), *Liquid*

text continued on next page

ABOUT THE CHARTS

Tabulated below are the key characteristics of more than a dozen oils, metals and salts. It should be noted that the charts show average properties, representative suppliers, and selected compounds. There are literally hundreds of variations and combinations. The AEC's excellent *Liquid Metals Handbook* lists, for instance, more than a score of liquid metals, half a hundred binary alloys and innumerable tertiary and quaternary compositions. Furthermore, for charting, some compounds have been grouped together (e.g. super-refined mineral oils and diesters) because they have similar properties even though made from entirely different materials.

Because producers and users of organic fluids generally speak in terms of kinematic viscosity, figures for those compounds are given in centistokes (cs). The liquid-metals industry, on the other hand, uses centipoises (cp), the units of absolute viscosity. To convert from absolute to kinematic, simply divide the absolute (cp) figure by the specific gravity. Nomographs for the conversion can be found in a number of petroleum and hydraulic handbooks, and in the transactions of the American Society of Lubricating Engineers.

HI-TEMP FLUIDS—*the Organics*

Fluid type	Phenyl Silicones	CFE fluids (chlorofluoroethylene)	Polyphenyl ethers (phenoxy phenyls	Chlorinated Polyphenyls	Developmental Fluorocarbon	Fluoroalkyl	Super-refined mineral oils and diesters
Pour Point, °F	−50	−90 to −20	20 to 60	50	−100	−5	< −40
Flash Point, °F	600	None	500 to 620	None	760	>550	450 to 600
Approx. useful-temperature range (open system)	−50 to 500	−20 to 500	40 to 700	50 to 600	−65 to 650	0 to 550	−40 to 600
Specific Gravity	1.1	1.9	1.2	1.5	—	1.8	0.9
Kinematic Viscosity (centistokes) 100F 500F	95 4	50 < 2	60 to 2800 0.6 to 3.0	400 to 525 0.8	35	715 2	30 1
Specific Heat, btu/lb/°F	0.6	0.3	0.5	0.8	—	0.4	0.7
Relative Lubricity	Poor to good	Fair to good	Good	Good	Good	Fair to good	Very good
Approximate Price ($/lb)	4.50 to 10	12	—	—	—	20	0.50 to 2
Suppliers and information sources	Dow-Corning General Electric Union Carbide	Hooker Chemical Pennsalt Halocarbon Prods.	Monsanto Dow Chemical Shell Development	Monsanto	E F Houghton	DuPont	Esso (oils) Lehigh (diesters)

Metals (SB 424), and *Molten Salts* (SB 425). Other excellent sources are the many papers on high-temperature fluids presented at recent design-engineering conferences and ASME and ASLE Meetings.

Points to check

Summing up, the major design problems and answers in using these high-temperature fluids lie in:

. . . clearly defining the operating range, viscosity and lubricity service life, and other critical requirements.

. . . selecting fluids and construction materials that are compatible in both directions—fluids which will not corrode containers, and containers which will not contaminate or corrode fluids.

. . . taking advantage of the special properties of such fluids as molten metals in selecting pumping and handling systems, while providing for their special problems—"freezing" at room temperature, for instance.

. . . compensating for the relatively poor lubricity and wide viscosity range of many of the materials with relatively slow, low-load designs.

. . . avoiding leakage, even where it may not pose fire hazards. These materials are far from inexpensive. It may be advisable to design a completely closed, sealed system even where an open one would otherwise be satisfactory and acceptable.

. . . compromising between good low-temperature and desirable high-temperature performance. Usually, the lower the pour point or melting point, the lower the flash point or boiling point. The organics that show greatest heat resistance are not very fluid at room temperature; and most of the metals, alloys, and salts are rock-hard until heat is applied.

Finally, remember that the 500-F-and-above fluids listed in the charts are those most popular and practical today—they are by no means the only ones under test. A raft of new organic fluids is being studied—many extremely promising though still fantastically high in cost.

Liquid rubidium is another brand-new material being put through its paces. Liquid sulfur is getting a full-scale test as a possible heat-exchange fluid or nuclear reactors and non-nuclear boilers.

The search for low-melting metals continues too—much of it under AEC contract—with attention being centered on ternary and quaternary alloys that might provide low-melting eutectics. One recent find: an unusually low-melting Co-Ce-Pu combination; this one of limited use, of course, but a good example of what may develop as research in this field continues.

EDITOR'S NOTE: For more on fluids and related design problems, see:

Modern Fluids for Power and Control, Jan 18 '60, p 56—A review of the better-known synthetics, and of the sealing materials used with them.

Hydraulic Fluids—Which Rubber-like Material? Mid-Sep '59, p 535. Compatibility table, solubility parameters, and other factors related to choice of sealing material.

For basic data on pumps and pump design, See **Positive-displacement Pumps,** June 6 '60, p 42—A roundup, with diagrams and tables, of all the major types. Also, **How Much Power to Pump Liquids? Feb 22 '60, p 59**—Nomographs for pump capacities from 0.1 to 1000 gpm, and pressures from 1 to 10,000 psi.

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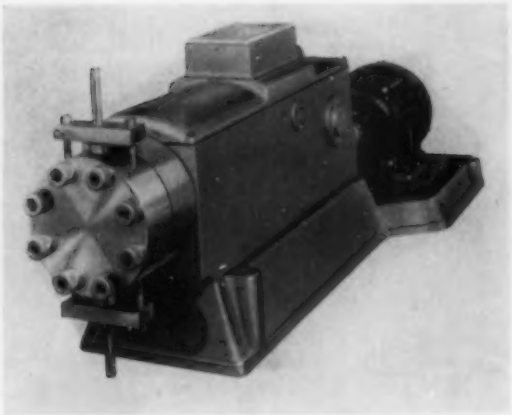
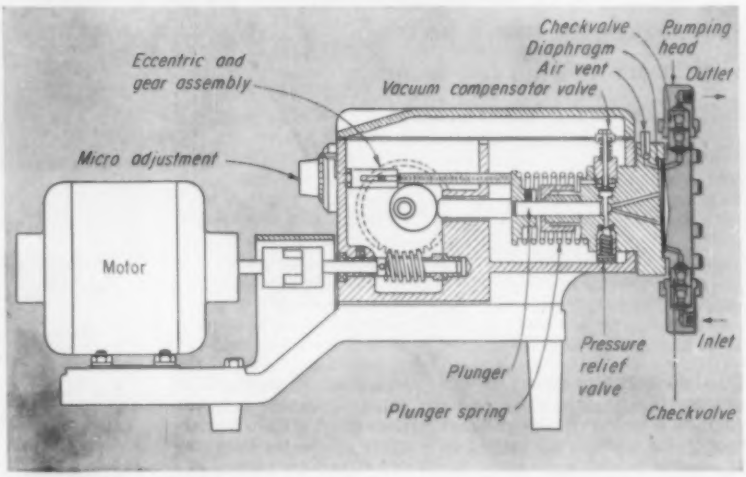


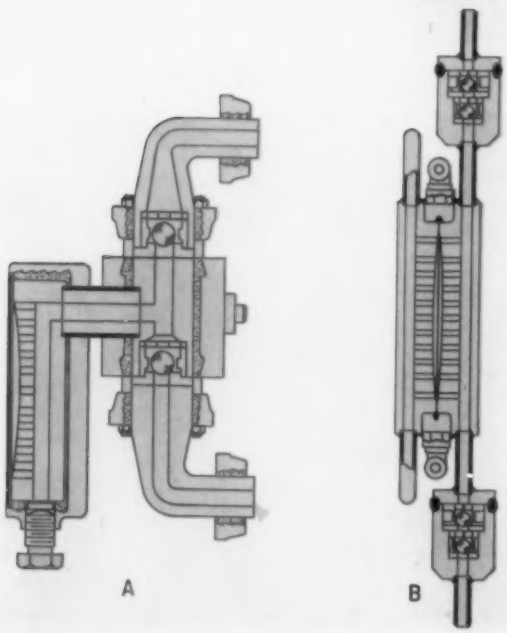
PRODUCT DESIGNS

The unit is two pumps in one—diaphragm actuated by hydraulic plunger. Only the diaphragm section handles the corrosive or otherwise troublesome fluid—comes in wide choice of pumping heads.

Pumps Oil to Pump Problem Fluids

PLUNGER PUMP is positive-displacement type, operated by an electric motor driving a worm and wheel. The eccentric mounted on wheel drives a rod against the pump plunger on the forward stroke; return stroke is powered by the plunger spring. The reciprocating plunger forces oil to move the diaphragm back and forth, producing the pumping action in the fluid-pumping head. Meanwhile, diaphragm serves as barrier, protecting inner pump from contact with the fluid. The pump is converted to pump different fluids by changing the entire pumping head.





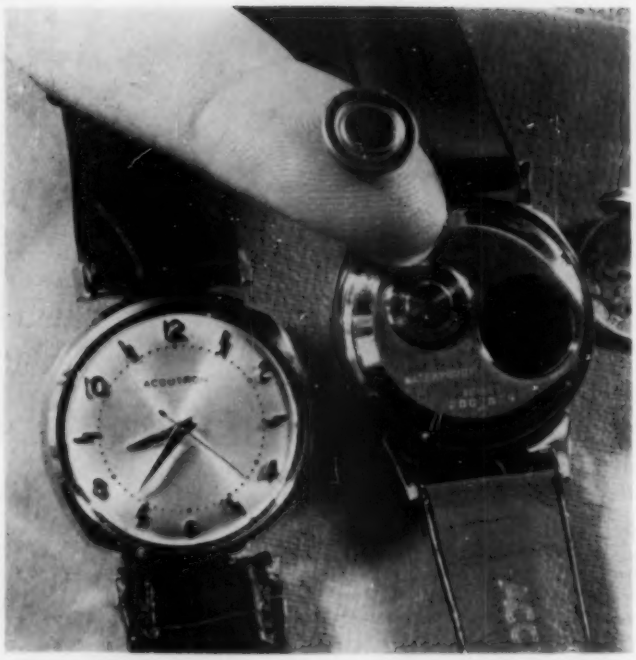
NONMETAL CONSTRUCTION (A) uses porcelain or glass with valve seats, gaskets and diaphragm of Teflon. This head will pump hydrochloric acid, mixed acid, metallic-salt solutions, or chlorinated and brominated componuds. Porcelain parts are covered with metal or fiberglass armor for mechanical protection.

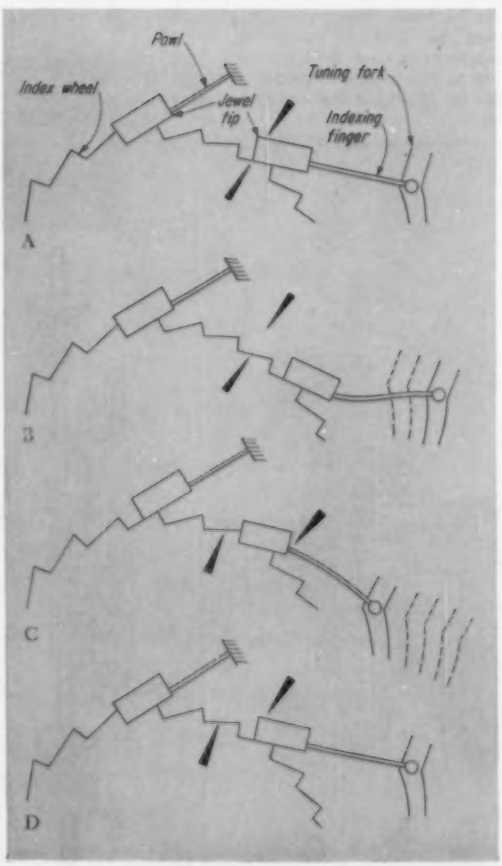
REMOTE HEAD (B) for dangerous solutions, will pump or meter liquids that are toxic, lethal or explosive. This primary head and its valves are installed in a sump or safety cell and connected by hydraulic line to a secondary pumping head, which is mounted in the pump itself. The primary head is leakproof, all-welded construction without gaskets or bolts. Remote heads can be operated submerged in heated or refrigerated liquids.

PS . . . Hundreds of head assemblies have been designed by the manufacturer for corrosive and hard-to-pump fluids such as hydrofluoric acid, aluminum sulfate, molten napthalene, liquefied gases, molten metals, metallic slurries, radioactive fluids. Replaceable heads allow using the unit as pump, chemical feeder, filling machine, proportioner, sampler, gas compressor or meter; and to handle flows from 1060 cm^3/hr to 720 gal./hr at pressures of 0 to 7000 psig. Microflow described above is smallest model of Pulsafeeder line by Process Equipment Div, Lapp Insulator Co, LeRoy, NY.

Transistorized Tuning Fork Runs Wristwatch

It's driven by an electronic circuit that makes the watch accurate within one minute per month. Replaceable power cell lasts one year.



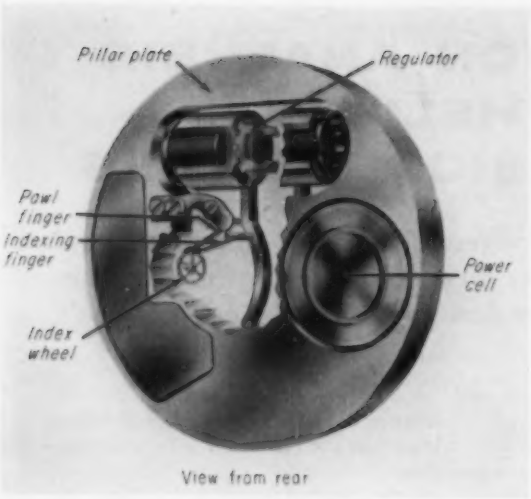


TUNING FORK replaces balance wheel as time standard in this watch. Its frequency remains constant at 360 cps, but amplitude may vary when watch is moved. To maintain accuracy, the mechanical part of the system allows for variation of amplitude within specified limits and electronic part of the system keeps amplitude within these limits.

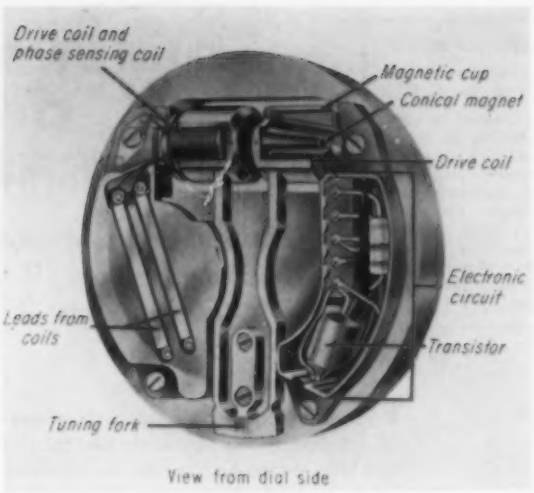
Post on one tine of the tuning fork carries jewel-tipped indexing finger which moves first gear in the train running to the hands. Average total excursion for indexing finger is two teeth. Starting from the center of a tooth (A) the finger moves back the equivalent of one tooth (B) and advances two to rotate the index wheel 1½ teeth (C). When the fork returns to center position, the finger retreats one tooth (D). While retreating, the finger and pawl rotate the wheel one half tooth backwards into contact with the holding pawl.

Although the indexing finger has a total excursion of two teeth, it only moves the indexing wheel one tooth. As long as amplitude remains between limits of slightly more than one tooth and slightly less than three teeth, wheel advance remains one tooth per cycle.

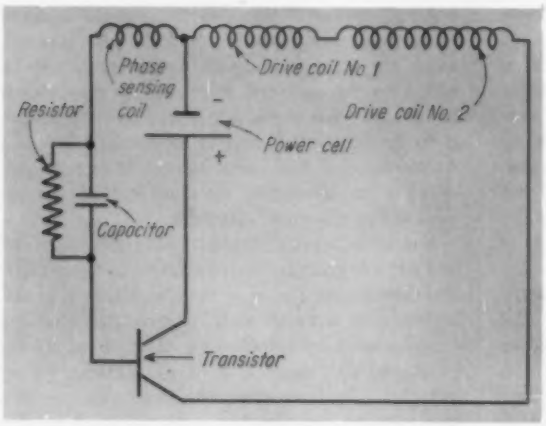
PS . . . Mercury power cell fits into recess in back of watch. Long life is possible because power drain is only 8 millionths of a watt. Accutron is manufactured to sell for from $175 to $2500 by Bulova Watch Co Inc.

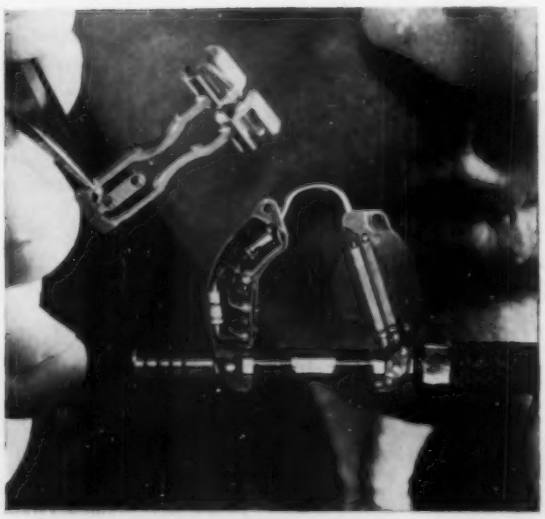


View from rear



View from dial side





TRANSISTORIZED ELECTRONIC CIRCUIT has two functions: drives the tuning fork; controls amplitude of tuning-fork vibration.

Transistor acts as a rectifier in the left-hand loop, and as switch in the right-hand loop. To trigger the switching function, voltage must be above a certain level, in this case slightly higher than the 1.3 v of the battery.

As the fork vibrates, it induces a voltage in both sensing and drive coils. When the fork moves in one direction, induced voltage in the sensing coil adds to battery voltage, sending an extra surge of current into the capacitor. Combined voltage is high enough to fire the transistor and complete the right-hand loop. During the time the transistor is conducting to the right-hand loop, current flows through the drive coils. Once each cycle, this current flow gives the fork enough push to maintain vibration.

When the fork changes direction, induced voltage in the sensing coil drops (then reverses); total voltage falls below that required to fire the transistor, and the transistor stops conducting. Between the time the transistor stops conducting and the next time it is fired, the capacitor has a chance to leak its charge through the resistor.

Voltage induced in the driving coils is put to work to keep tuning-fork amplitude within set limits. If amplitude weren't limited, linkage from the fork would pick up more or less teeth on the index wheel, and advance the watch hands an incorrect amount. Amplitude determines voltage induced in the driving coils. At the time the transistor passes current, this induced voltage opposes battery voltage. Normally this induced voltage is 10% lower than battery voltage; but when amplitude is too large, the difference is less than 10% so the push given by the coils to the fork is less. When amplitude is too small, the difference is greater than 10% and coils push the fork more.

MODULES—Transistorized circuit and coils are one unit; tuning fork with magnets are another. Both are replaced, but not repaired, by watchmakers.

NICHOLAS MILLER
Dole Valve Co
Morton Grove, Ill

We regret to announce that Mr Miller died shortly after preparing this article. He was associated with Hotpoint Co and Dole Valve Co for 30 years in the capacities of mechanical engineer and designer.

DIMENSION ANALYSIS OF HELICAL COMPRESSION SPRINGS

If standard tolerances aren't good enough, you must specify your own. Where do you start? The author's method tells you and shows how to hold down costs as well.

The most economical helical compression springs call for dimensional tolerances that are in accordance with established standards. But sometimes the more rigid requirements of a particular design won't allow this. Then you must tighten some of the tolerances. The money-saving way to do this is to give the spring manufacturer some leeway by making the remaining tolerances as liberal as possible. This calls for analysis of the tolerances that affect the following spring parameters: (1) force increment; (2) deflection increment; (3) spring-rate increment; (4) shear-stress increment. The tolerances involved are those on wire diameter, mean coil diameter, the number of effective coils, and the free spring length.

The equations presented in the comprehensive table at right give a clearer picture of the effect of a combination of tolerances on spring parameters, thus speeding up calculations. In addition, the table shows approximate versions of those equations; the approximations save still more time, yet retain accuracy. Here is how they apply to each parameter:

1. *Force Increment*

When a spring is compressed to a fixed or constant length, the resulting force can be calculated in terms of the nominal spring dimensions by the standard spring equation, shown in the comprehensive table. However, the actual force produced is influenced by the four dimensional tolerances Δd, ΔD, Δn, and ΔL. The free length tolerance ΔL modifies the actual deflection; the tolerance on the number of active coils affects the deflection per coil.

In the standard equation for force, the four dimensional tolerances can combine with the nominal spring dimensions to produce a maximum or a minimum force. When it is maximum, the corresponding force increment is to be added to the nominal force and is represented by ΔF_+. When it is minimum, the increment is to be subtracted, and is represented by ΔF_-. Assuming the four dimensional tolerances are effective simultaneously, the exact force-ratio equations are as shown in the table.

But since normal manufacturing tolerances Δd and ΔD are generally small relative to their nominal dimensions, the exact equations shown in the table can be replaced with approximate equations (also shown) by substituting $(1 \pm 4\ \Delta d/d)$ for $(1 \pm \Delta d/d)^4$, and $(1 \pm 3\ \Delta D/D)$ for $(1 \pm \Delta D/D)^3$. In both cases the maximum positive and negative increments can be averaged to give an average maximum increment. In either the exact or approximate equations the effect of any one of the dimensional tolerances can be obtained by setting the other three tolerances to zero and tabulating the resulting tolerance as shown. The values of the average force-ratio,

$$\frac{\Delta F}{F_{AVE}}$$

are obtained by discarding the higher powers of ΔD and Δn.

text continued on p 54

SYMBOLS

d — Wire dia, in.
Δd — Wire-dia tolerance, in.
D — Mean coil dia, in.
ΔD — Mean coil-dia tolerance, in.
C — Spring index $\left(\frac{D}{d}\right)$
F — Nominal spring force, lb
ΔF — Spring force increment due to dimensional tolerances, lb
G — Torsional modulus, psi
L — Free length of compression spring, in.
ΔL — Free-length tolerance, in.
n — Number of active coils
Δn — Active-coils tolerance
f — Nominal deflection of spring at a given force, in.
Δf — Deflection increment due to dimensional tolerances
σ — Nominal spring rate, lb/in. $\left(\frac{F}{f}\right)$
$\Delta\sigma$ — Spring-rate increment due to dimensional tolerances, lb/in.
S — Nominal shear stress, psi.
ΔS — Shear-stress tolerance, psi

COMPREHENSIVE TABLE—INCREMENT RATIOS AND TOLERANCES DERIVED FROM STANDARD EQUATIONS

Standard Equations		Increment Ratios	Tolerances Δd	Tolerances ΔD	Tolerances Δn	Tolerances ΔL
Force $F = \frac{Gfd^4}{8nD^3}$	Exact Equations	$\frac{\Delta F_+}{F_{MAX}} = \frac{\left(1+\frac{\Delta L}{f}\right)\left(1+\frac{\Delta d}{d}\right)^4}{\left(1-\frac{\Delta n}{n}\right)\left(1-\frac{\Delta D}{D}\right)^3} - 1$	$\left(1+\frac{\Delta d}{d}\right)^4 - 1$	$\frac{1}{\left(1-\frac{\Delta D}{D}\right)^3} - 1$	$\frac{\Delta n}{n-\Delta n}$	$\frac{\Delta L}{f}$
		$\frac{\Delta F_-}{F_{MAX}} = 1 - \frac{\left(1-\frac{\Delta L}{f}\right)\left(1-\frac{\Delta d}{d}\right)^4}{\left(1+\frac{\Delta n}{n}\right)\left(1+\frac{\Delta D}{D}\right)^3}$	$1-\left(1-\frac{\Delta d}{d}\right)^4$	$1-\frac{1}{\left(1+\frac{\Delta D}{D}\right)^3}$	$\frac{\Delta n}{n+\Delta n}$	$\frac{\Delta L}{f}$
	Approx. Equations	$\frac{\Delta F_+}{F_{MAX}} = \frac{\left(1+\frac{\Delta L}{f}\right)\left(1+4\frac{\Delta d}{d}\right)}{\left(1-\frac{\Delta n}{n}\right)\left(1-3\frac{\Delta D}{D}\right)} - 1$	$4\frac{\Delta d}{d}$	$\frac{1}{1-3\frac{\Delta D}{D}} - 1$	$\frac{\Delta n}{n-\Delta n}$	$\frac{\Delta L}{f}$
		$\frac{\Delta F_-}{F_{MAX}} = 1 - \frac{\left(1-\frac{\Delta L}{f}\right)\left(1-4\frac{\Delta d}{d}\right)}{\left(1+\frac{\Delta n}{n}\right)\left(1+3\frac{\Delta D}{D}\right)}$	$4\frac{\Delta d}{d}$	$1-\frac{1}{1+3\frac{\Delta D}{D}}$	$\frac{\Delta n}{n+\Delta n}$	$\frac{\Delta L}{f}$
	Average	$\frac{\Delta F}{F_{AVE}} = \pm\frac{1}{2}\left(\frac{\Delta F_+}{F} + \frac{\Delta F_-}{F}\right)$	$\pm 4\frac{\Delta d}{d}$	$\pm 3\frac{\Delta D}{D}$	$\pm\frac{\Delta n}{n}$	$\pm\frac{\Delta L}{f}$
Deflection $f = \frac{8FnD^3}{Gd^4}$	Exact Equations	$\frac{\Delta f_+}{f_{MAX}} = \frac{\left(1+\frac{\Delta n}{n}\right)\left(1+\frac{\Delta D}{D}\right)^3}{\left(1-\frac{\Delta d}{d}\right)^4} - 1$	$\frac{1}{\left(1-\frac{\Delta d}{d}\right)^4} - 1$	$\left(1-\frac{\Delta D}{D}\right)^3 - 1$	$\frac{\Delta n}{n}$	
		$\frac{\Delta f_-}{f_{MAX}} = 1 - \frac{\left(1-\frac{\Delta n}{n}\right)\left(1-\frac{\Delta D}{D}\right)^3}{\left(1+\frac{\Delta d}{d}\right)^4}$	$1-\frac{1}{\left(1+\frac{\Delta d}{d}\right)^4}$	$1-\left(1-\frac{\Delta D}{D}\right)^3$	$\frac{\Delta n}{n}$	
	Approx. Equations	$\frac{\Delta f_+}{f_{MAX}} = \frac{\left(1+\frac{\Delta n}{n}\right)\left(1+3\frac{\Delta D}{D}\right)}{\left(1-4\frac{\Delta d}{d}\right)} - 1$	$\frac{1}{1-4\frac{\Delta d}{d}} - 1$	$3\frac{\Delta D}{D}$	$\frac{\Delta n}{n}$	
		$\frac{\Delta f_-}{f_{MAX}} = 1 - \frac{\left(1-\frac{\Delta n}{n}\right)\left(1-3\frac{\Delta D}{D}\right)}{\left(1+4\frac{\Delta d}{d}\right)}$	$1-\frac{1}{1+4\frac{\Delta d}{d}}$	$3\frac{\Delta D}{D}$	$\frac{\Delta n}{n}$	
	Average	$\frac{\Delta f}{f_{AVE}} = \pm\frac{1}{2}\left(\frac{\Delta f_+}{f} + \frac{\Delta f_-}{f}\right)$	$\pm 4\frac{\Delta d}{d}$	$\pm 3\frac{\Delta D}{D}$	$\pm\frac{\Delta n}{n}$	
Spring Rate $\sigma = \frac{F}{f} = \frac{Gd^4}{8nD^3}$	Exact Equations	$\frac{\Delta\sigma_+}{\sigma} = \frac{\left(1-\frac{\Delta d}{d}\right)^4}{\left(1-\frac{\Delta D}{D}\right)^3\left(1-\frac{\Delta n}{n}\right)} - 1$	$\left(1+\frac{\Delta d}{d}\right)^4 - 1$	$\frac{1}{\left(1-\frac{\Delta D}{D}\right)^3} - 1$	$\frac{\Delta n}{n-\Delta n}$	
		$\frac{\Delta\sigma_-}{\sigma} = 1 - \frac{\left(1-\frac{\Delta d}{d}\right)^4}{\left(1+\frac{\Delta D}{D}\right)^3\left(1+\frac{\Delta n}{n}\right)}$	$1-\left(1-\frac{\Delta d}{d}\right)^4$	$1-\frac{1}{\left(1+\frac{\Delta D}{D}\right)^3}$	$\frac{\Delta n}{n+\Delta n}$	
	Approx. Equations	$\frac{\Delta\sigma_+}{\sigma} = \frac{\left(1+4\frac{\Delta d}{d}\right)}{\left(1-3\frac{\Delta D}{D}\right)\left(1-\frac{\Delta n}{n}\right)} - 1$	$4\frac{\Delta d}{d}$	$\frac{1}{1-3\frac{\Delta D}{D}} - 1$	$\frac{\Delta n}{n-\Delta n}$	
		$\frac{\Delta\sigma_-}{\sigma} = 1 - \frac{\left(1-4\frac{\Delta d}{d}\right)}{\left(1+3\frac{\Delta D}{D}\right)\left(1+\frac{\Delta n}{n}\right)}$	$4\frac{\Delta d}{d}$	$1-\frac{1}{1+3\frac{\Delta D}{D}}$	$\frac{\Delta n}{n+\Delta n}$	
	Average	$\frac{\Delta\sigma}{\sigma_{AVE}} = \pm\frac{1}{2}\left(\frac{\Delta\sigma_+}{\sigma} + \frac{\Delta\sigma_-}{\sigma}\right)$	$\pm 4\frac{\Delta d}{d}$	$\pm 3\frac{\Delta D}{D}$	$\pm\frac{\Delta n}{n}$	

HELICAL SPRINGS

continued

2. *Deflection Increment*

Frequently the deflection at a given load must be held within specified limits, and in these cases the effect of the dimensional tolerances on the deflection becomes of primary importance. This is done by rearranging the standard spring equation, as shown in the table. The exact and approximate equations for the deflection increments are determined and tabulated in the same manner as the corresponding ones for force increments were. Similarly, the individual tolerances for these equations are determined and tabulated, and the final equations for deflection ratios and deflection increment are calculated.

3. *Spring-rate Increment*

The spring force divided by the deflection is commonly known as the spring rate, and many applications where the working length is variable require specified spring rates. In such cases it is desirable to know the effect of the tolerances upon the spring-rate increment. This is done quite easily by again rearranging the standard spring equation and tabulating the results, as shown in the table. Since the spring-rate ratio varies directly with F, the tolerances produce similar results; the only difference is that the length tolerance, ΔL, has no effect on the spring rate.

4. *Shear-stress Increment*

Variations in the tolerances also result in variation of shear stresses in the spring. Generally, they are not important enough in this respect to affect the specifications of the spring. For this reason the results are not incorporated in the table, but following equations can be tabulated when necessary.

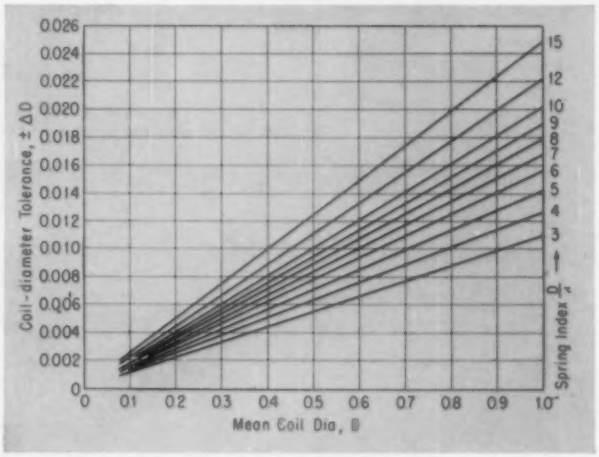
At a given deflection the nominal stresses are obtained by the equation:

$$S = \frac{Gdf}{\pi n D^2}$$

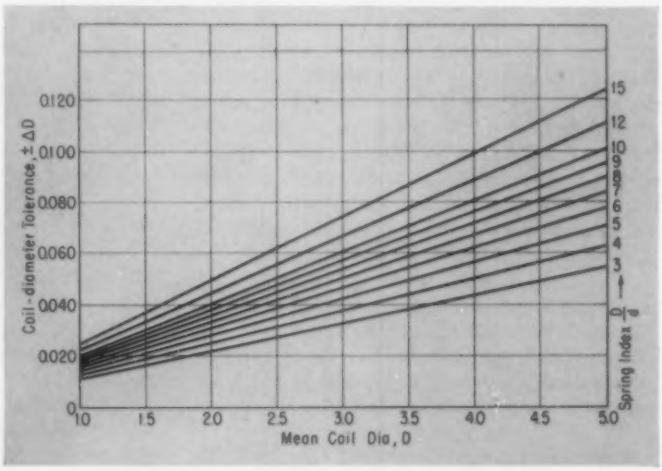
The shear stresses are maximum when tolerances Δd and ΔL are positive, and when ΔD and Δn are negative; they are minimum when Δd and ΔL are negative and ΔD and Δn are positive. Following the procedure for the force increment, approximate value of the stress increment is:

$$\Delta S = \pm S\sqrt{\left(\frac{\Delta d}{d}\right)^2 + \left(2\frac{\Delta D}{D}\right) + \left(\frac{\Delta n}{n}\right) + \left(\frac{\Delta L}{f}\right)^2}$$

PUTTING THE



a



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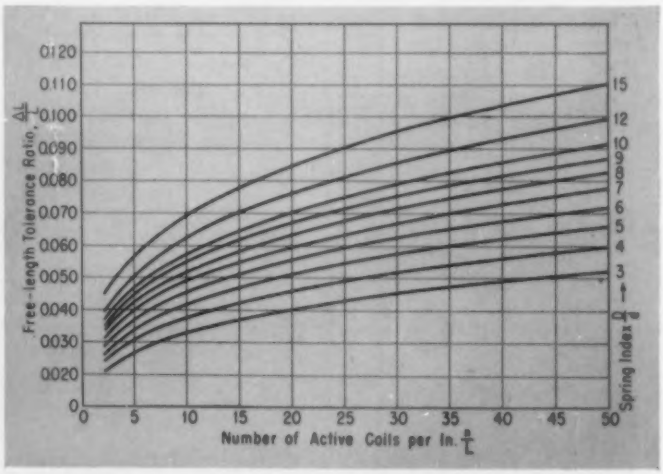
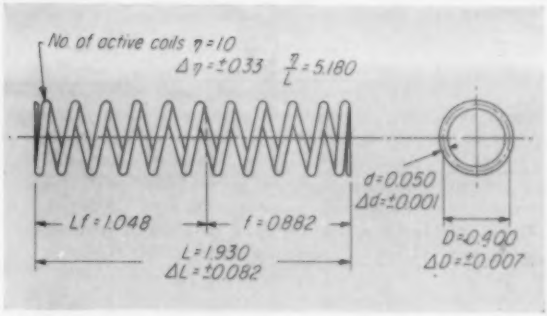


c

COIL-DIAMETER TOLERANCES for springs with (a) mean coil diameters up to 1 in. and spring indices from 3 to 15; (b) mean coil diameters 1 to 5 in., and spring indices 3 to 15; (c) free-length tolerance ratios, $\Delta L/L$, for springs with indices 3 to 15.

EQUATIONS TO WORK

Here is an example showing how to use the simplified method to solve a typical problem. Commercial standards for the example are listed in the tabular material on page 57. These tolerances represent available commercial standards. Various spring manufacturers have their own standards, some of which may be more precise than those shown.



COMMERCIAL TOLERANCES of sample spring with 10 active coils and spring index of 10.

■ Suppose a nominal force $F = 12.27$ lb, based on a nominal shear stress of 10^6 psi, is required to produce a deflection of 0.882 in., giving a spring rate of 13.90 lb/in. for the spring shown. Tolerances are computed by the new method to give a complete dimensional analysis (see table, next page). These tolerances are based on standards shown in diagrams at left, and tables on p 57.

Numerical results show how closely the tolerances from the approximate equations match those of the exact equations. The increment-force ratios are greatest for free-length tolerance, followed by Δd, ΔD and Δn in that order. The increment-deflection ratios are greatest for Δd, followed by ΔD and Δn. Here the free length has no effect, because the deflection ratios are independent of the length. The spring-rate ratios are the same as the deflection ratios, except that free length has no effect. For this reason, their values for the sample spring are not given.

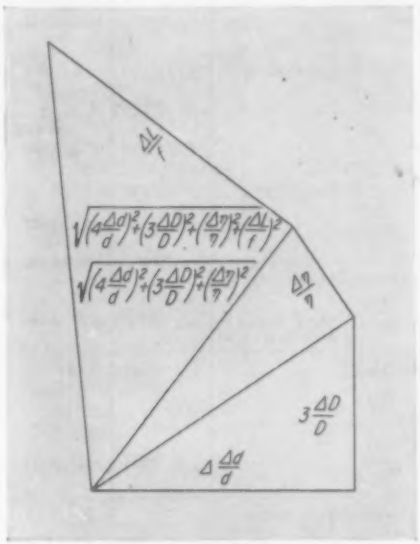
The values for the average increment ratios based on exact and approximate equations are in close agreement, so the average increment and most probable value of the increments can be expressed in simplified equations shown on next page together with corresponding values for the sample spring.

The "average" increment values are the largest possible since they are based on the nominal dimensional tolerances. However, in the fabrication of springs subject to effective quality control, the dimensional tolerances will vary from zero to their nominal (which is also their maximum) value. Hence the cases in which all four tolerances combine to produce either a maximum or minimum increment will be rare.

In general, the probable value of the increment will be between $\frac{1}{2}$ and $\frac{3}{4}$ of its maximum value. So, it is more practical to use the "probable" value of the increments, which are derived from the "average" increment equations in accordance with the distributive laws. The value of the quantity under the radical is conveniently obtained graphically by a succession of right triangles as shown in diagram at right.

The numerical values for the sample spring show that the probable value of the force increment ΔF is ± 1.69, based on the commercial tolerances. If this force tolerance is permissible, then the sample spring could be produced at a minimum cost.

However, should the conditions of design limit the force tolerance; for example, to ± 1.00 lb, it would then be necessary to reduce the tolerance in the equation with the radical so that a force tolerance of ± 1.00 will result. But reduction of tolerance Δd would require specially fabricated wire at increased cost and possible delay in availability. In this case it would be better to apply the commercial tolerance to the wire and coil diameters, and specify the nominal number of active coils and the free length as approximate. This would allow the spring manufacturer to vary these to produce the spring force 12.27 ± 1.00 lb at the deflected length of 1.048 in. (length minus deflection).



GRAPHICAL METHOD simplifies calculation of probable values for increments of force, deflection and spring rate.

Similarly, the numerical value for the probable deflection increment is ± 0.089 based on the commercial tolerances. Should the conditions of design limit the variations in the deflected length to ± 0.050, then the three dimensional tolerances in the equation with the radical must be reduced to give ± 0.050. An alternate method would be to specify the nominal wire and coil diameters, leaving the number of coils approximate, and allow the spring manufacturer to vary these to produce the spring with a deflection of 0.882 ± 0.50 in.

Any limitations on the probable spring-rate increment

CALCULATED INCREMENT RATIOS AND TOLERANCES FOR SAMPLE SPRING

Increment Ratios	Tolerances				Increment Ratios (based on sum of single tolerances)	Increment Ratios (based on tolerances taken simultaneously)
	Δd	ΔD	Δn	ΔL		
Force (Exact Equations) $\frac{\Delta F+}{F_{MAX}}$	0.0824	0.0543	0.0341	0.0930	0.2638	0.2900
$\frac{\Delta F-}{F_{MAX}}$	0.0776	0.0507	0.0319	0.0930	0.2532	0.2312
$\frac{\Delta F}{F_{AVE}}$	±0.0800	±0.0525	±0.0330	±0.0930	±0.2585	±0.2606
Force (Approx. Equations) $\frac{\Delta F+}{F_{MAX}}$	0.0800	0.0554	0.0341	0.0930	0.2625	0.2884
$\frac{\Delta F-}{F_{MAX}}$	0.0800	0.0499	0.0319	0.0930	0.2548	0.2325
$\frac{\Delta F}{F_{AVE}}$	±0.0800	±0.0527	±0.0330	±0.0930	±0.2587	±0.2605
Deflection (Exact Equations) $\frac{\Delta f+}{f_{MAX}}$	0.0842	0.0534	0.0330		0.1706	0.1798
$\frac{\Delta f-}{f_{MAX}}$	0.0762	0.0516	0.0330		0.1608	0.1527
$\frac{\Delta f}{f_{AVE}}$	±0.0802	±0.0525	±0.0330		±0.1657	±0.1663
Deflection (Approx. Equations) $\frac{\Delta f+}{f_{MAX}}$	0.0870	0.0525	0.0330		0.1725	0.1818
$\frac{\Delta f-}{f_{MAX}}$	0.0741	0.0525	0.0330		0.1596	0.1516
$\frac{\Delta f}{f_{AVE}}$	±0.0800	±0.0525	±0.0330		±0.1655	±0.1667

SAMPLE SPRING—EQUATIONS AND VALUES FOR AVERAGE AND PROBABLE INCREMENTS

Increment	Average Increment		Probable Increment	
	Equation	Value	Equation	Value
Force	$\Delta F = \pm F\left(4\frac{\Delta d}{d} + 3\frac{\Delta D}{D} + \frac{\Delta n}{n} + \frac{\Delta L}{f}\right)$	±3.17	$\Delta F = \pm F\sqrt{\left(4\frac{\Delta d}{d}\right)^2 + \left(3\frac{\Delta D}{D}\right)^2 + \left(\frac{\Delta n}{n}\right)^2 + \left(\frac{\Delta L}{f}\right)^2}$	±1.69
Deflection	$\Delta f = \pm f\left(4\frac{\Delta d}{d} + 3\frac{\Delta D}{D} + \frac{\Delta n}{n}\right)$	±0.146	$\Delta f = \pm f\sqrt{\left(4\frac{\Delta d}{d}\right)^2 + \left(3\frac{\Delta D}{D}\right)^2 + \left(\frac{\Delta n}{n}\right)^2}$	±0.089
Spring Rate	$\Delta\sigma = \pm\sigma\left(4\frac{\Delta d}{d} + 3\frac{\Delta D}{D} + \frac{\Delta n}{n}\right)$	±2.300	$\Delta\sigma = \pm\sigma\sqrt{\left(4\frac{\Delta d}{d}\right)^2 + \left(3\frac{\Delta D}{D}\right)^2 + \left(\frac{\Delta n}{n}\right)^2}$	±1.400

of ±1.40 lb can be treated similarly. The spring rate for the sample spring should be gaged between two force or deflection limits and specified as: 13.90 ± 1.40 lb/in. between 9.6 and 11.6 lb or 13.90 ± 1.40 lb/in. between deflected lengths of 1.24 and 1.10 in.

It should be noted that the equations are based on dimensions with equal bilateral tolerances. Dimensions with unequal or unilateral tolerances are to be transformed to the equal bilateral form with the same limits. For example, if the coil diameter is specified as $D = 0.400$, $+0.008$ in. and -0.006 in., then for use in the formulas the equal bilateral tolerance becomes $\pm\frac{1}{2}(0.008 + 0.006) = 0.007$ in. and the corresponding dimension is 0.401 in., giving the limits 0.408 max, 0.394 min. If the specified coil diameter is $D = 0.400$, $+0.014$ in. and -0.000 in., then the equal bilateral tolerance is $\pm\frac{1}{2}(0.014 + 0.000) = \pm 0.007$ in. with the corresponding dimension of 0.407 in. and the limits 0.414 max, 0.400 min.

Although it is improbable that with effective quality control the four dimensional tolerances will combine to produce a max or min effect; it is quite probable that single tolerances can occur at their max or min value. For this reason the available space should be checked against the max and min dimensions of the spring.

The spring manufacturer could adjust the coiling machine to compensate for the variations in the wire diameter to obtain a specified force, deflection, or spring rate. The following tabulation shows the variations in the single dimensions required to compensate for ±0.001 in. variation in the wire diameter of the sample spring.

Variation	Compensatory Dimensional Variations		
Δd	ΔD	Δn	ΔL
±0.001	±0.011	±0.800	∓0.071

The compensatory variations in ΔD or Δn exceed the normal manufacturing tolerances; therefore, to meet restricted specifications with respect to force, deflection or spring rate, it is desirable to make the tolerances flexible so that they may be distributed and excessive individual variations avoided. ■

EDITOR'S NOTE—Additional information on many other factors involved in spring design may be found in the following articles:

How to Predict Buckling and Unseating of Coil Springs, July 18 '60, p 62—Here are the latest equations for predicting what happens when coil springs are compressed between parallel or nonparallel plates.

How Light a Spring for Absorbing Shock?, Feb 1 '60, p 49—You don't even have to know the spring's dimensions; these equations quickly find the lightest type needed to absorb impact of a mass. Dimensions can later be varied at will without affecting the weight analysis.

How to Design Multirate Helical Springs, Jan 20 '58 p 76—Two special methods for assembling springs in series to obtain multirate characteristics.

Your Guide to Springs That Store Energy Best, Nov 10 '58, p 71—Equations and tables that give definite comparisons among many materials and spring types.

29 Ways to Fasten Springs, Dec 21 '59, p 66—A rundown of ingenious attachments for extension, compression and torsion springs.

Wire Gage Number

Wire diameter for springs is generally specified in decimals according to a gage number. There are three gage systems in use in the US for round spring wire.

Washburn and Moen Gage, also known as Steel Wire Gage, is used for hard-drawn or oil-tempered spring wires and for alloy-steel spring wires. Between each of the original W & M gage numbers, three additional or split-gage numbers, designated as ¼, ½ and ¾, have been inserted, reducing the steps of consecutive wire diameters by 0.007 in. for the larger sizes, beginning with No 7/0 or 0.490 in. diameter. The smaller sizes, below 0.010 in. diameter, vary by 0.0001-in. steps.

Music Wire Gage developed by American Steel and Wire Co is for piano or music wire with sizes varying from No 6/0 or 0.0040 in. to No 45 or 0.1800 in. diameter.

American Wire Gage (same as Brown and Sharp Gage) is for all nonferrous round spring wire with sizes varying from No 4/0 or 0.4600 in. to No 40 or 0.0031 in. diameter.

MUSIC WIRE TOLERANCES

Diameter	Tolerances
Up to 0.0160	+0.000,25–0.000,00
0.0160 to 0.0620	+0.000,50–0.000,00
0.0620 to 0.0800	+0.001,00–0.000,00
0.0800 to 0.1040	±0.0010
0.1040 to 0.1440	±0.0015
0.1440	+0.0020

(data from Spring Manufacturer's Assn)

WIRE TOLERANCES—CARBON STEEL, HARD-DRAWN OR OIL-TEMPERED

Diameter	Tolerances
Up to 0.0750	±0 0010
0.0750 to 0.3750	±0.0020
0.3750	±0.0030

(from 1957 SAE Handbook)

VALVE SPRING QUALITY AND ALLOY STEEL WIRE TOLERANCES

Diameter	Tolerances
Up to 0.1480	±0.0010
0.1480 to 0.1770	±0.0015
0.1770 to 0.3750	±0.0020
0.3750	±0.0030

(from 1957 SAE Handbook)

TOLERANCES ON COPPER-BASE ALLOY SPRING WIRES

Diameter	Tolerances	
	Brass	Phosphor-Bronze & Beryllium Copper
Up to 0.0100	±0.0001	±0.0002
0.010 to 0.0200	±0.0002	±0.0003
0.0200 to 0.0300	±0.0003	±0.0005
0.0300 to 0.0400	±0.0004	±0.0007
0.0400 to 0.0500	±0.0005	±0.0008
0.0500 to 0.0600	±0.0006	±0.0010
0.0600 to 0.0800	±0.0008	±0.0015
0.0800 to 0.1500	±0.0010	±0.0020
0.1500 to 0.5000	±0.0015	±0.0020

(data by H. C. R. Carlsen, PE—Feb '49 p 103)

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, N. Y.

Veeder-Root READOUT Bulletin

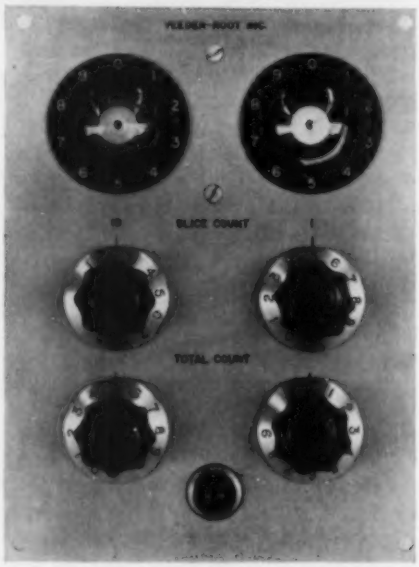
New Electronic Counters provide simplified operation, automatic control for Original Equipment

Veeder-Root Electronic Predetermining Counters are now being used to improve machine efficiency by providing varying degrees of automatic control as original equipment.

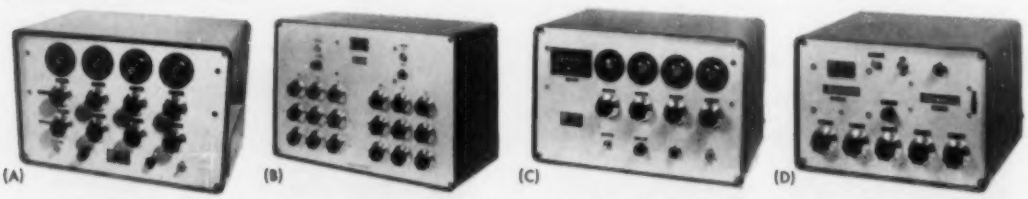
These new electronic counters count electrical impulses. This makes them extremely versatile — and suited to design innovation — because these pulses can be supplied by photoheads, snap-action switches, mechanical contactors, impact and proximity switches, and the like. Photohead actuation alone has almost limitless application potential, and is ideal for high velocity, non-contact counting at any stage of a machine's operation.

The predetermining action — which actuates machine controls, signals, etc., — can run the extreme from a single stop motion, with only one bank of selector knobs all the way to multiple banks which are used to set up a series of stop motions, usually sequentially. There is no theoretical limit on the number of banks (or sequential stops) that can be provided. Counting speeds are available up to 5000 counts per second, and even higher in special applications. Instantaneous reset and automatic recycling are also valuable features.

Some of the many possible counter variations are shown below. Both the 1804 Series, Electronic, and 1601 Series, Electric, Counters are providing this type of control as original equipment on a variety of machines, from bacon slicers to plastic film extruding machines. Design and engineering assistance is available to help achieve maximum operating efficiency for your equipment.

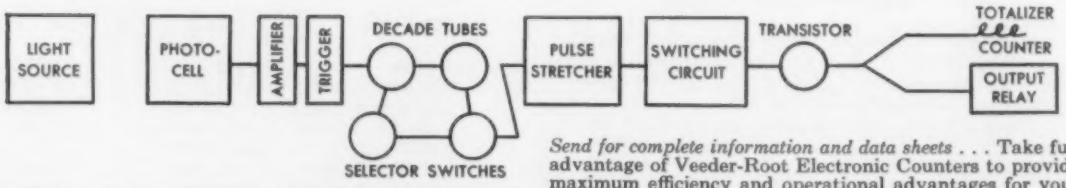


This is a panel mounted Series 1804 Predetermining Counter designed to control operation of a bacon slicing machine. Top bank of knobs is preset to number of slices in each package, other set controls total number of units or packages.



These are a few of the variations in predetermining control available with the Veeder-Root Series 1601 Electric and 1804 Electronic Counters. (A) For measuring film footage; when number on top set of dials is reached machine is slowed down, then stops when lower number is reached. (B) Series 1601 Counter, designed for sequential control based on six preset quantities. (C) A four figure counter incorporating a batch totalizer. (D) Series 1601 Counter with five figures, one set of preset numbers and a totalizer for counting cycles or batches.

Simplified Schematic of the Veeder-Root Series 1804 Electronic Counter



Veeder-Root Electronic Counters are designed to your specific requirements. These are some of the many operations now being performed with this modern control method.

measuring	batching mixes	packaging rolls
bin loading	can counting	coil winding
pill packaging	bread slicing	labeling machines
tube cut off	cap counting	nail packaging
bag counting	flow measurement	conveyor control
tool control	predetermining revolutions	

Send for complete information and data sheets . . . Take full advantage of Veeder-Root Electronic Counters to provide maximum efficiency and operational advantages for your equipment. Contact your nearest Veeder-Root Counting Engineer, or write direct.

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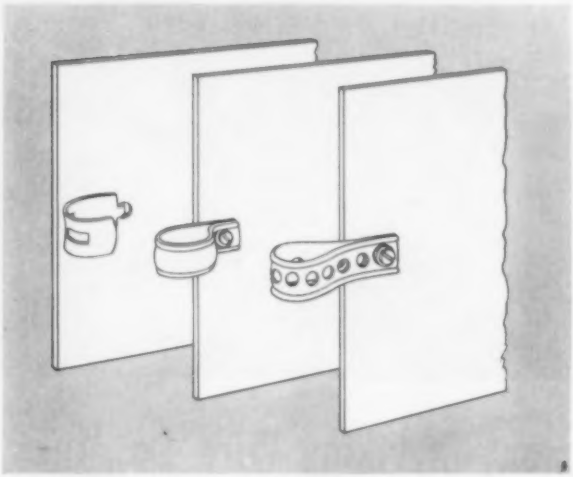
VRO-24

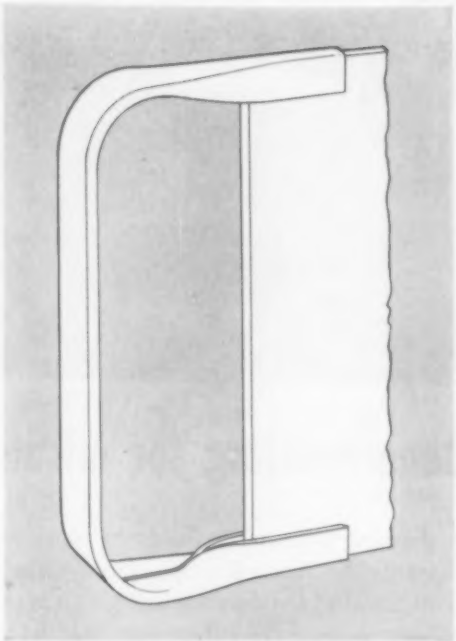
7 more HANDLES for PRINTED CIRCUITS

A handy guide to easy withdrawal and handling of these circuit boards. An earlier selection was presented in the Oct 10 issue.

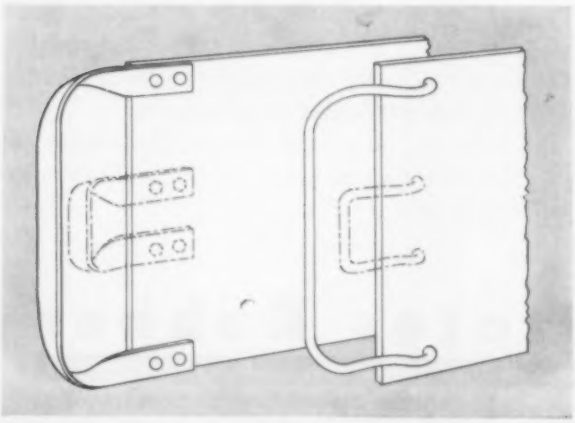
I N SCHUSTER, *product design engineer*
Raytheon Co
Wayland, Mass



1 CABLE CLAMPS AND STRAPS are readily available in many styles. By using solderable materials, handles can be assembled during component-soldering operation.



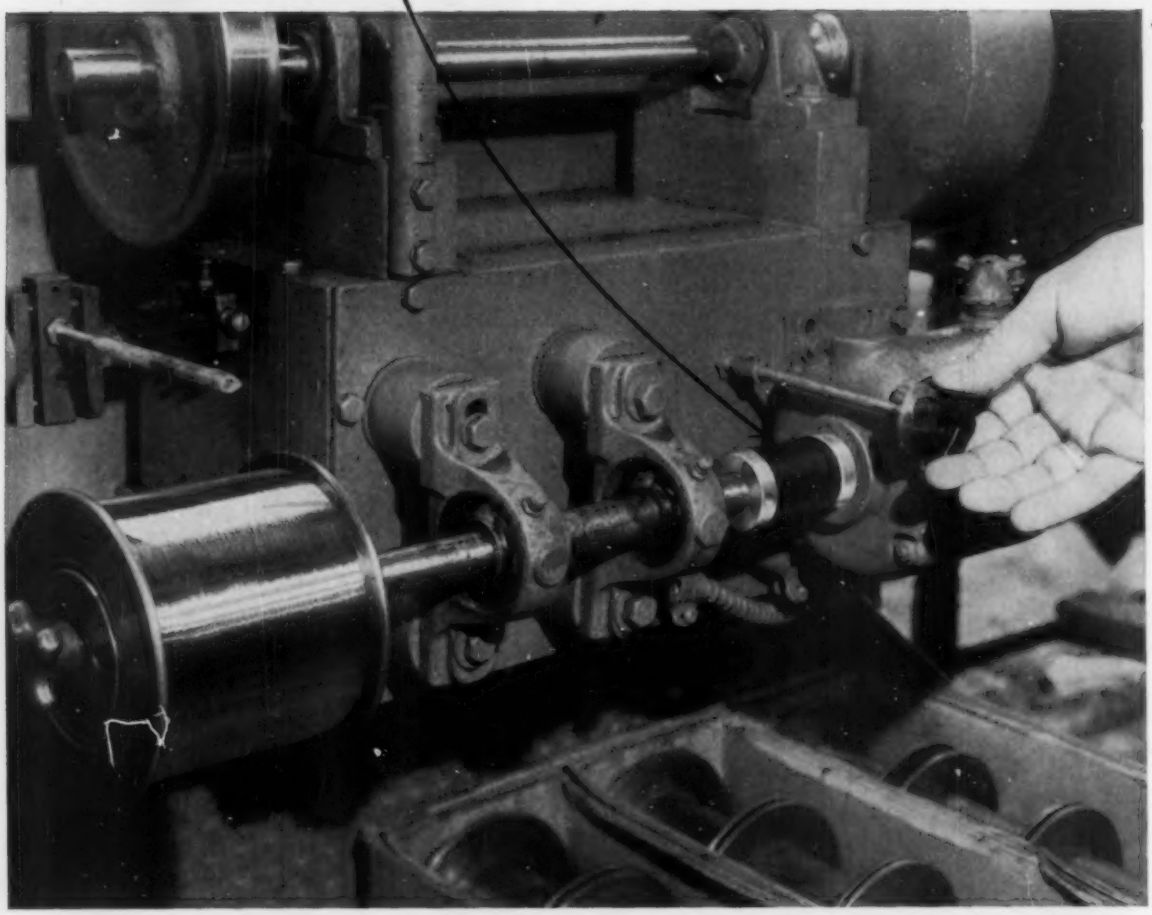
2 MORE COMPLEX SHAPE of sheetmetal handle is often preferred when appearance is an important feature of the design.



3 WIRE OR SHEETMETAL parts may be easily formed either as full handles or fingergrips.

continued on page 61

FLEXIBLE COUPLINGS



Compensating for misalignment in Viking Wire Co., Inc.

Wire drawing subjects machines to considerable shock loads. The Viking Wire Co., Inc. has a battery of 26 machines in the drawing room. This is one of the newest plants in the industry and has the latest in machinery, equipment and methods.

"U.S." Flexible Couplings were selected for all the machines (see picture) principally to absorb shock loads and compensate for misalignment. Other reasons for selection were ease of installation, lack of maintenance or lubrication and just plain overall efficiency.

These couplings are so simple in design that the cost is very low compared with other couplings. Insist on having these tried on your machinery—and then watch your costs go down.

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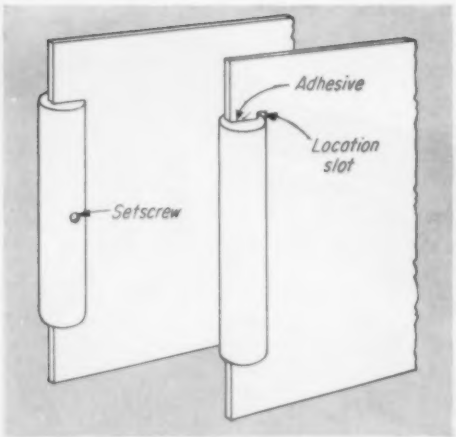
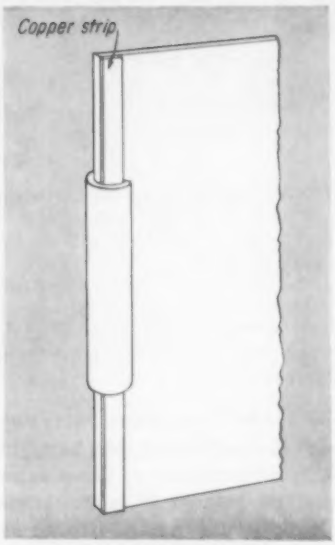
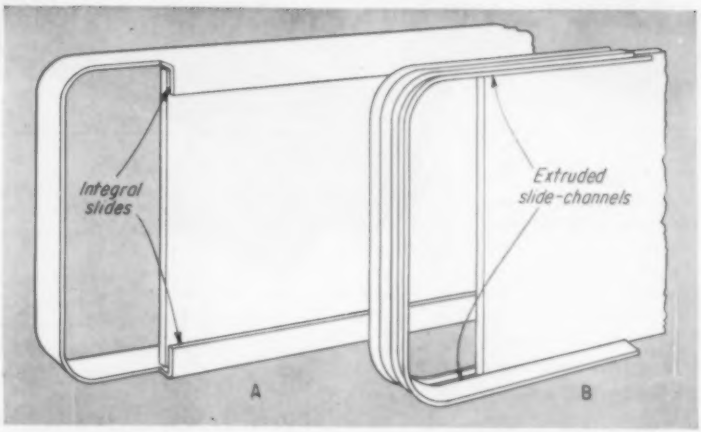


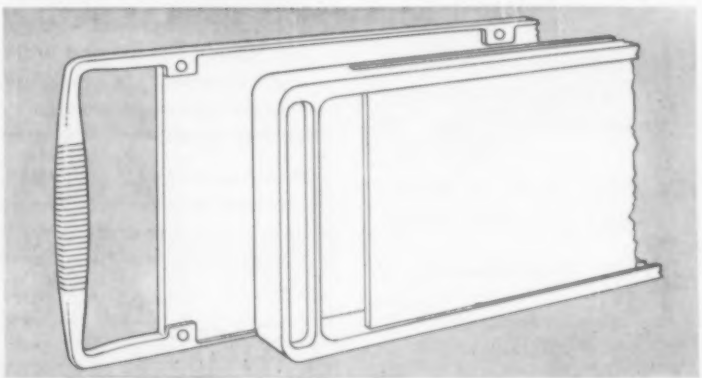
4 SLOTTED ROD, held by either a screw or adhesive, is most suitable when more robust fastening is required.



5 SPLIT TUBING can be slipped onto panels and retained by spring effect, or a copper strip can be left to provide a shoulder.



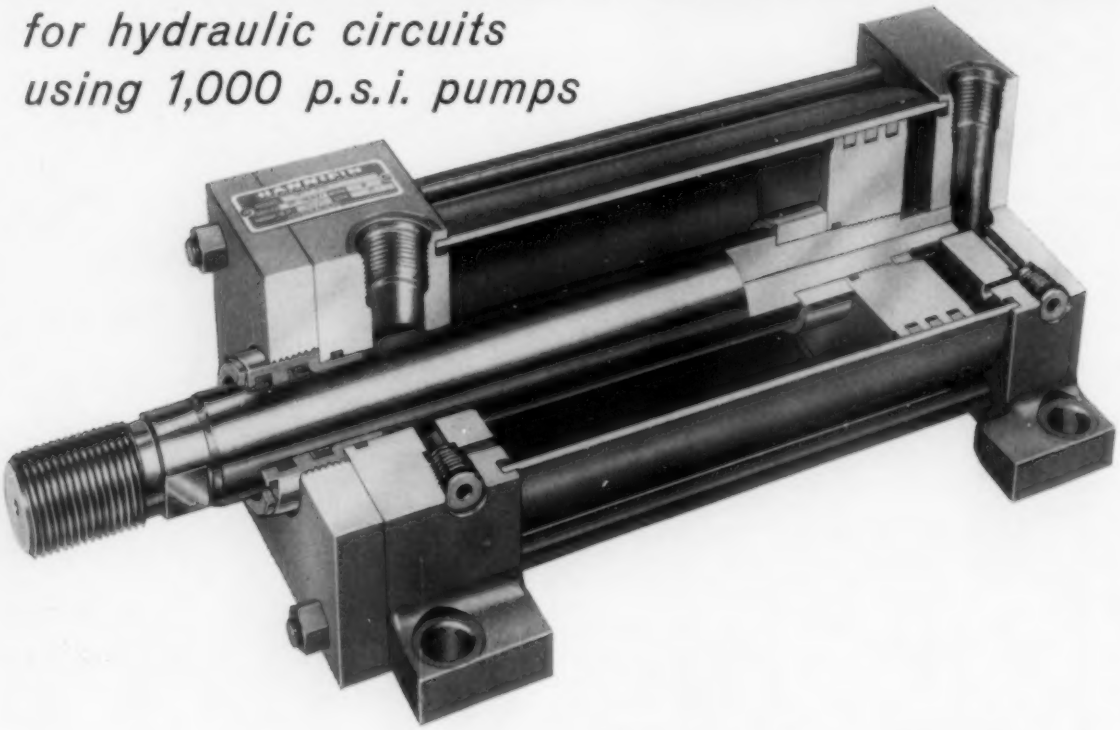
6 BOARD-STIFFENING FRAMES have integral slide surfaces and handles. Method suitable for either press-forming (A) or extrusion (B).



7 DIE-CAST AND MOLDED handles can be provided if needed in quantity large enough to justify added cost of tooling.

NEW FROM HANNIFIN
THE THOUSAND POUND LINE!

for hydraulic circuits
using 1,000 p.s.i. pumps



- *A true hydraulic cylinder – not a modified air cylinder*
- *Offered in nine bore sizes – 1" through 8"*
- *Every model withstands at least 1,000 p.s.i. in every bore size*
- *Built to save you money – yet not "built to a price"*

Now, for the first time in hydraulic cylinder manufacture, Hannifin offers a top quality cylinder tailored to the medium-high-pressure hydraulic circuits you operate off 1,000 p.s.i. pumps.

Series "L," the "Thousand Pound Line," is NOT a modified heavy duty air cylinder. It is built for the job . . . with steel heads and steel barrel for full compliance with J.I.C. hydraulic recommendations. Other extra-quality features include an induction hardened and hard chrome plated rod, nodular iron piston with cast-iron piston rings — leakproof "Lipseals®," optional — longer cushions on cushioned models, and the Hannifin-developed bronze cartridge gland with both "Lipseal®" and "Wiperseal" to keep the rod drip-free. S.A.E. straight thread "O" ring ports as recommended by J.I.C. are optional at no extra cost just as they are in the Hannifin heavy duty Series "H" hydraulic cylinder.

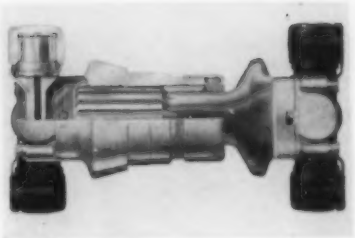
Parker-Hannifin field engineering service can help you meet your needs precisely, help you select the proper Hannifin cylinder for any service, air or hydraulic. Call your nearest Parker-Hannifin sales office or write direct for our new bulletin giving all dimensions of Hannifin Series "L" cylinders.

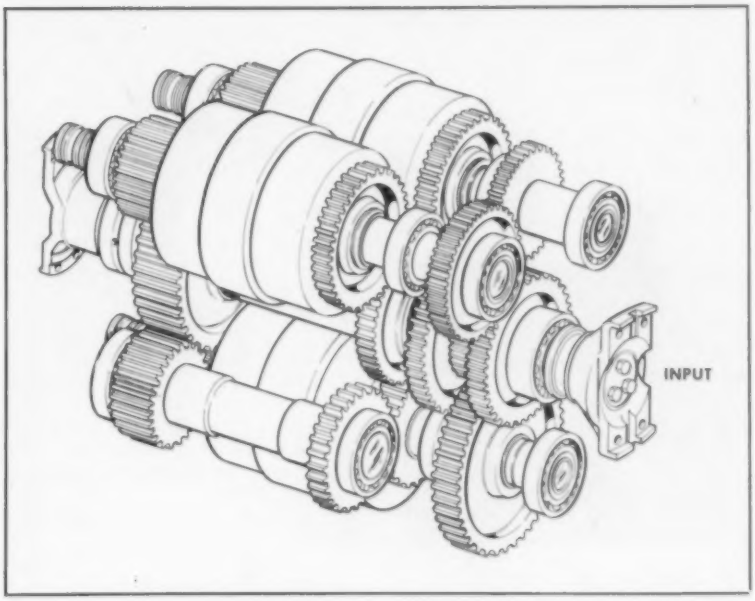
PARKER HANNIFIN CORPORATION

HANNIFIN COMPANY
A DIVISION
525 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

2077-PH

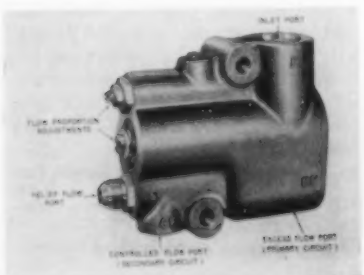
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES





Integrated power-transmission components . . . from engine to axle for heavy-duty vehicles include torque-converter, six-speed transmission and universal joint. Transmission has five speeds forward, one reverse, for engines developing up to 420 net hp at up to 2100 rpm. It is straight-through, countershaft-type with constant-mesh gearing and oil-cooled, hydraulically actuated clutches. If desired, internal gearing can be rearranged to give three speeds forward, three reverse. An 18-in., single-stage torque-converter with freewheeled stator, hydraulic retarder and lockup clutch for direct drive is also available. Three sets of gear ratios will be offered. Selector valve provides eight shift positions: reverse; neutral; first; second; second, third, fourth and fifth lockup. Manual override can give converter drive in all ranges. Line of universal joints is being produced under exclusive license of Glenkwellenbau GmbH, West Germany. Converter, retarder and five-speed transmission (complete unit) priced in range of $6500 list. Now in pilot production; full production scheduled for April 1961. **Twin Disc Clutch Co, Hydraulic Div, Rockford, Ill.**

Circle 300 on Reader Service Card



Flow-divider valve . . . directs output from one pump to either of two or more hydraulic circuits, or to all circuits simultaneously. Flow-proportion adjustments permit diversion of desired portion of pump output to secondary circuit when primary circuit is inactive, then automatically reduces or stops secondary flow when primary circuit is pressurized. Pump flow enters inlet port, passes through orifice and out controlled flow port to operate secondary circuit. Entire pump output is delivered to controlled-flow port until pressure differential across orifice depresses springloaded plunger, opening passage to excess-flow port and primary circuit. Built-in relief valve protects pump from over-pressure at controlled flow port. Operates on low circulation pump pressure, handling all standard hydraulic fluids at up to 250 F. Nine models are available, with or without manual controlled flow adjustment, and range in capacity from 15 to 80 gpm. **Fawick Hydraulic-Electronic Div, Fawick Corp, 9919 Clinton Rd, Cleveland 11.**

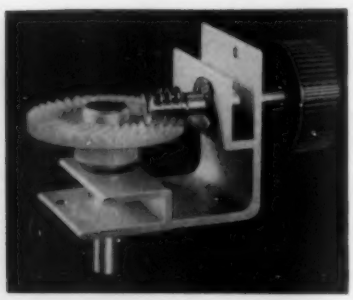
Circle 301 on Reader Service Card

Magnet-operated limit switch . . . for repetitive, high-reliability applications operates without physical contact of levers, rods or shafts. As permanent magnet passes near face of switch, normally open

continued on page 64

contact to reopen. Permanent magnets can be installed on any portion of equipment to be controlled. In addition, both magnet and switch can be fixed and switch operated by passing vane of magnetic material between the two. Magnets are either ⅜ in. dia x 2½ in. long or 1 1.18 in. dia x 7 in. long. Switch is available with contact ratings of 0.75 amp make, 0.2 amp carry and break at 115 v ac. Response time is 0.001 sec. When used with dc, switch requires arc suppression, which varies with circuit parameters. **General Electric Co, Schenectady 5.**

Circle 302 on Reader Service Card



Antibacklash adjuster . . .

was developed for tuning potentiometers, magnitron tuners, variable condensers and coils, but can also serve as hand-operated inputs to mechanical equipment. Lightly spring-loaded to take up minute tooth-to-tooth deviations, gear adjustment in mounting provides constant tooth contact. Assembly is available with gear assembly capacity of 20 in.-lb, hand-operated. Normal ratio is 19½:1. **Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.**

Circle 303 on Reader Service Card

1-hp printed dc servo motor . . .

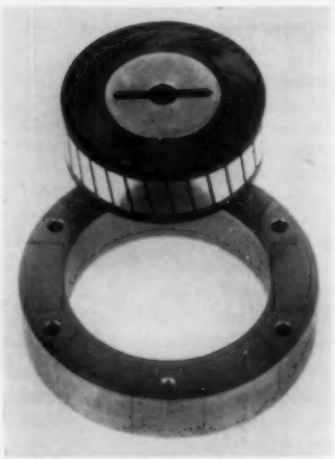
is for operation at 2500 rpm. 1⅝ in. thickness is made possible by use of barium ferrite or similar ceramic magnets. Weighs 15 lb. Performance advantages of ceramic magnet, 1-hp motor are being extended to other printed circuit models now in production with Alnico magnets and having continuous-duty rated torque values of 12, 42.5, 150 and 1000 in.-oz. Use of ceramic magnets instead of Alnico magnets results in about 3:1 reduction in shaft torque output. Prototypes are $1500, with 6-wk delivery. In quantities of 1000, price drops to $280 each, with production delivery of 50 per wk. In lots of 200, motors are $350 each. **Photocircuits Corp, 31 Sea Cliff Ave, Glen Cove, NY.**

Circle 304 on Reader Service Card

Direct-writing photo paper . . .

originally developed for use in direct-writing oscillographs is available in standard and ultrathin weights (0.0045 and 0.0025 in. thick). Writing speed is up to 40,000 in. per sec, approaching speed of fastest conventional photorecording paper available. High-contrast tracing is reported to last indefinitely with proper handling, because it is dry-process photorecording paper. Development or intensification takes place in ordinary room light, with image appearing in 15 to 30 sec. Available in 100- to 475-ft rolls, 6 to 12 in. wide. Priced from $8.10 to $66.65 per roll, list. **E I du Pont de Nemours & Co Inc, Photo Products Dept, Wilmington 98, Del.**

Circle 305 on Reader Service Card



Pancake dc torque motors . . .

are for use as high-performance torquers or direct servomotors. Multipole, permanent-magnet torque motors measure 3¾ in. OD x 1⅜ in. ID x 1 in. thick. Offers 2.2 in.-oz torque per w with peak torque of 165 in.-oz. **Giannini Controls Corp, 1600 S Mountain Ave, Duarte, Calif.**

Circle 306 on Reader Service Card

Air-hardening die steel . . .

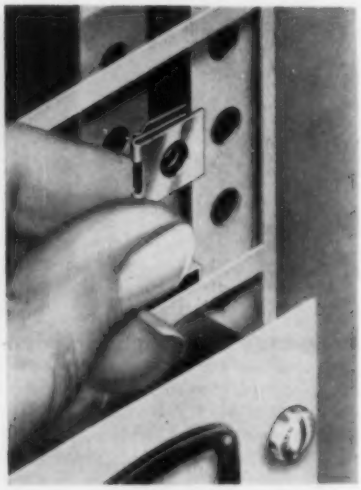
is said to have hardening temperature low enough so that it can be heat-treated without use of expensive furnaces. Free-machining properties are reported to be 40% better than conventional oil-hardening steels used for the same type of dies. It is 10% min tougher than these oil-hardening grades. **Crucible Steel Co of America, Pittsburgh 22.**

Circle 307 on Reader Service Card

Pressure-sensitive felt tape . . .

in three types are for sound-deadening, cushioning, dust and moisture sealing, and insulating applications. Available as untreated felt with adhesive on one side and protective backing; asphalt-treated felt with pressure-sensitive adhesive; wax-impregnated felt, chromate treated. Adheres to most types of surfaces. Available in various thicknesses and widths, packaged in rolls. **Presstite Div, American-Marietta Co, 39th and Chouteau Ave, St Louis 10.**

Circle 308 on Reader Service Card



Clip-on receptacle . . .

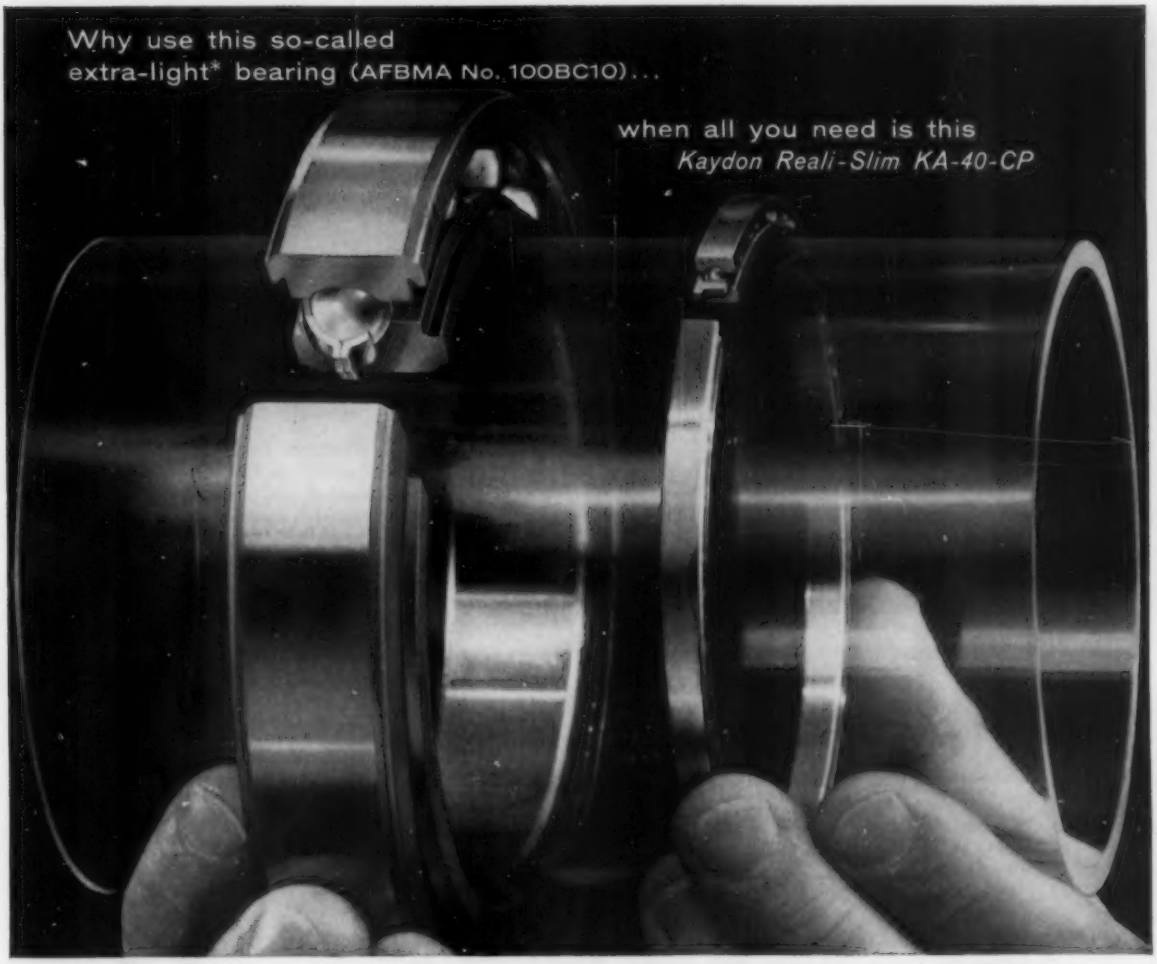
for quarter-turn fasteners is made of hardened steel, cadmium-plated. Receptacle slips on over punched or drilled hole and locks in place. Clip accommodates frame thicknesses of 0.055 to 0.090 in. Tolerates misalignment of parts. Stud, which goes into receptacle, is slipped through hole in door and kept there with split-ring retainer. Fasteners with clip-on receptacles are available in oval and flush head styles. **Southco Div, South Chester Corp, Industrial Highway, Lester, Penna.**

Circle 309 on Reader Service Card

Open center cam index drive . . .

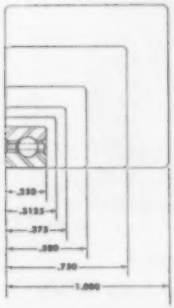
can be used to index tables that experience high thrust and/or radial loading conditions on trunnion and dial type automated machines, stationary center column machines and special machine tools. Sealed cam-index drive is said to have excellent stability, with follower plate

continued on page 66



News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

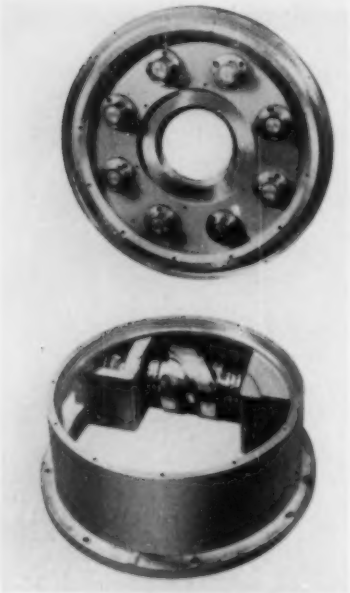
Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160



thrust rating of over 31,000 lb and tipping moment rating of 380,000 in.-lb. Follower plate of cam index drive rides on X-bearing, which is mounted around periphery of follower plate and accepts loads in all directions. Standard index drives are available with integral gear reducer for use on tables from 20 to 120 in. dia. Index accuracy is reported to be ±0.003 in. at outside edge of 36-in. dia table. **Expert Automation Machine Co, 17144 Mt Elliott Ave, Detroit 12.**

Circle 310 on Reader Service Card

Dial indicating thermometers

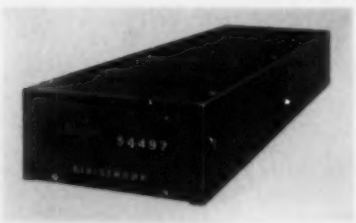
have crowned acrylic lens, raised graduations to reduce parallax error, adjustable bracket allowing for mounting variations of 150 degrees on horizontal axis, case that rotates 90 degrees in either direction on vertical axis, adjustable pointer and sliding union connection nut that allows 3 to 15-in. immersion. Three models include solid liquid filled unit (shown) that provide 279 angular degrees of evenly graduated arc; vapor-pressure-actuated type using single bourdon tube and multiplying mechanism; and bimetal thermometer employing a thermostatic bimetal helix sensing element. **Electric Autolite Co, Industrial Instrument Div, Port Huron, Mich.**

Circle 311 on Reader Service Card

High-temperature spring wire . . .

for springs to be operated at temperatures to 1800 F is vacuum-melted, nickel-base alloy wire. Available annealed to spring tempers in 0.2 to 0.004 in. dia. Tensile strength in spring temper ranges from 250,000 to 280,000 psi. Modulus of elasticity ranges from 31.6 million psi at room temperature to 20 million psi at 1700 F. Priced from about $19 to $39 per lb. **National-Standard Co, Niles, Mich.**

Circle 312 on Reader Service Card



Digital display . . .

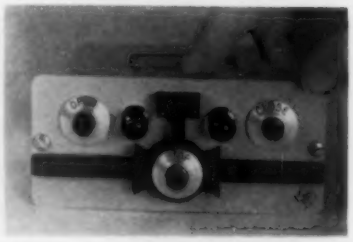
employs stroboscopic principle to provide in-line, in-plane, high-definition, white-on-black display. Through use of shutter arrangement, single diode-encoding matrix is shared by all columns. Single display can be used to sample several inputs on command, replacing as many as 15 individual displays of existing types. Operates directly from output register of computer, counter or allied equipment. Operates on single-phase, 60 cps, 115 v power. Min strobe tube life is 2000 hr. Max transition time from display quantity to display quantity is said to be 56 millisec. Measures 2 x 4 x 15¾ in. deep, complete. Characters are 0.226 in. high. **Kearfott Div, General Precision Inc, Little Falls, NJ.**

Circle 313 on Reader Service Card

Intermediate-hp motors . . .

to match performance curves of hydraulic pumps are available in 12 intermediate ratings as standard, off-the-shelf units. Rating include 2½, 4, 6¼, 8¾, 12½, 17½, 22½, 27½, 32½, 35, 37½ and 45 hp. Other conventional ratings from ½ through 60 hp are also offered. Hydraulic pump mount motors hook up by internal spline coupling method. Suitable for all makes of flange-mounted hydraulic pumps. Supplied with flange end bell and spline coupling. Can be furnished in polyphase, dripproof and totally enclosed units, in frame sizes from 182 through 365-U. **Reuland Electric Co, Alhambra, Calif.**

Circle 314 on Reader Service Card



Remote indicating control unit

provides remote open-stop-close or on-off control and status indication of power-operated devices with only two wires between remote point and central control location. Packaged with graphic symbol front cover for use in central graphic display panel. Max loop line resistance can be to 100 ohm for incandescent indications or 2000 ohm for neon indicators. Standard field unit is suitable for controlling up to 2 amp coils at 480 v with larger capacities available. **Texas Instruments Inc, 3609 Buffalo Speedway, Houston 6.**

Circle 315 on Reader Service Card

Diaphragm-operated adjustable pressure switches

include model equipped with three-way, snap-action valve for pneumatic control systems and model equipped with SPDT explosion-proof, UL- and CSA-approved switch for electric control. Standard pressure-operating range can be adjusted from 6 to 15 psi. Standard units for pneumatic and electrical control systems

continued on page 68

Wherever in the world your hydraulic machinery operates . . .

Shell Tellus Oil is there

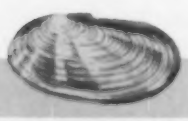
Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Rimula Oils** – for heavy-duty diesel engines
- **Shell Talona R Oil 40** – anti-wear crankcase oil for diesel locomotives
- **Shell Alvania Grease** – multi-purpose industrial grease
- **Shell Turbo Oils** – for utility, industrial and marine turbines
- **Shell Dromus Oils** – soluble cutting oils for high-production metalworking
- **Shell Macoma Oils** – for extreme pressure industrial gear lubrication
- **Shell Voluta Oils** – for high-speed quenching with maximum stability

Around the world, Shell Tellus Oil is available—under the same brand name and providing the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

No matter where your hydraulic machinery is shipped, make Shell Tellus Oil your standard recommendation. Write for complete information.



AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the **Cultellus** costatus.

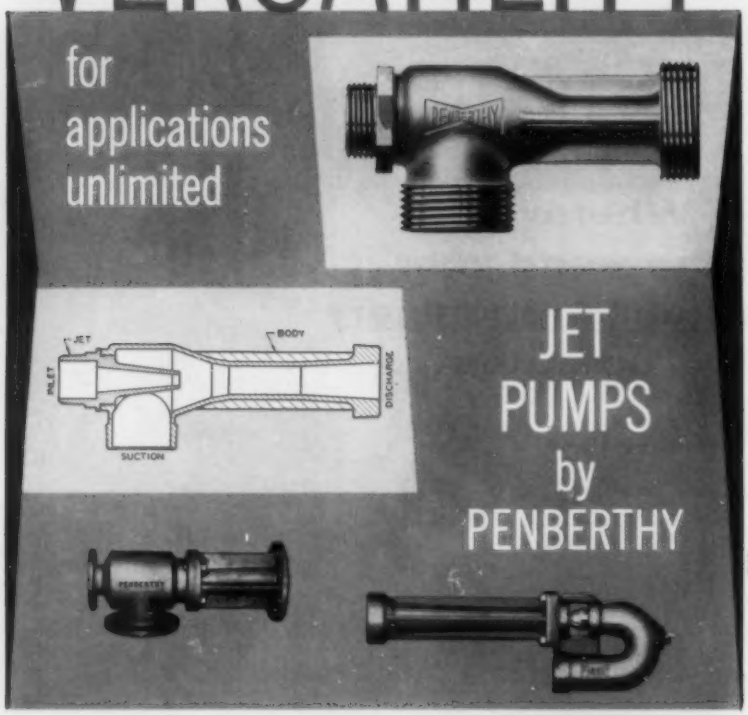
SHELL OIL COMPANY

50 WEST 50TH STREET.....NEW YORK 20, N.Y.
100 BUSH STREET.....SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO

SHELL

CIRCLE 67 ON READER SERVICE CARD

VERSATILITY



There's hardly a basic manufacturing or service industry that hasn't a use for Penberthy Jet Pumps. And the list of OEM products embodying Jet Pump applications is virtually endless, too. Small wonder, for wherever there's a fluid, vapor, gas or slurry handling job to be done . . . aerate, agitate, blend, circulate, dilute, exhaust, filter, heat, mix, pump or transfer . . . there you'll find an application for *versatile* Penberthy Jet Pumps.

And consider the advantages . . . small in size, light in weight . . . construction and operation simplicity . . . low initial cost, low installation cost, little or no maintenance cost. And in many cases Penberthy Jet Pumps can be utilized where mechanical pumps are impractical or uneconomical. Want more information? Send the coupon below or call your nearby Penberthy engineer today.

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

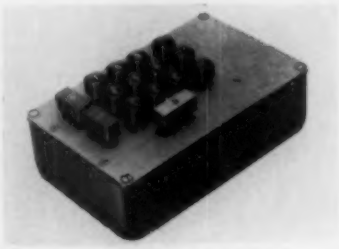
PENBERTHY
Dedicated to Quality Since 1886

GENTLEMEN: Would like more information.
Please send your Jet Pump Catalog #512R.

NAME_____ TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

are $38 and $68, respectively, FOB Tulsa. Delivery, 2 wk. **Instruments Inc, PO Box 556, Tulsa, Okla.**

Circle 316 on Reader Service Card



Contactless electronic keyboard . . .

switches without metallic contact, eliminating malfunction from corrosion, oxidation, wear and humidity and contact-bounce and noise of electromechanical keyboards. Power requirements are 600 milliw. Can be made with any number of keys and any type of coding. Operating on dc, keyboard produces coded dc output. To derive desired output characteristics, various additional circuits can be introduced, including trigger, pulse generator, multivibrator and memory circuits. **Amelco Inc, 12964 Panama St, Los Angeles 66.**

Circle 317 on Reader Service Card

Valve uses squeeze action . . .

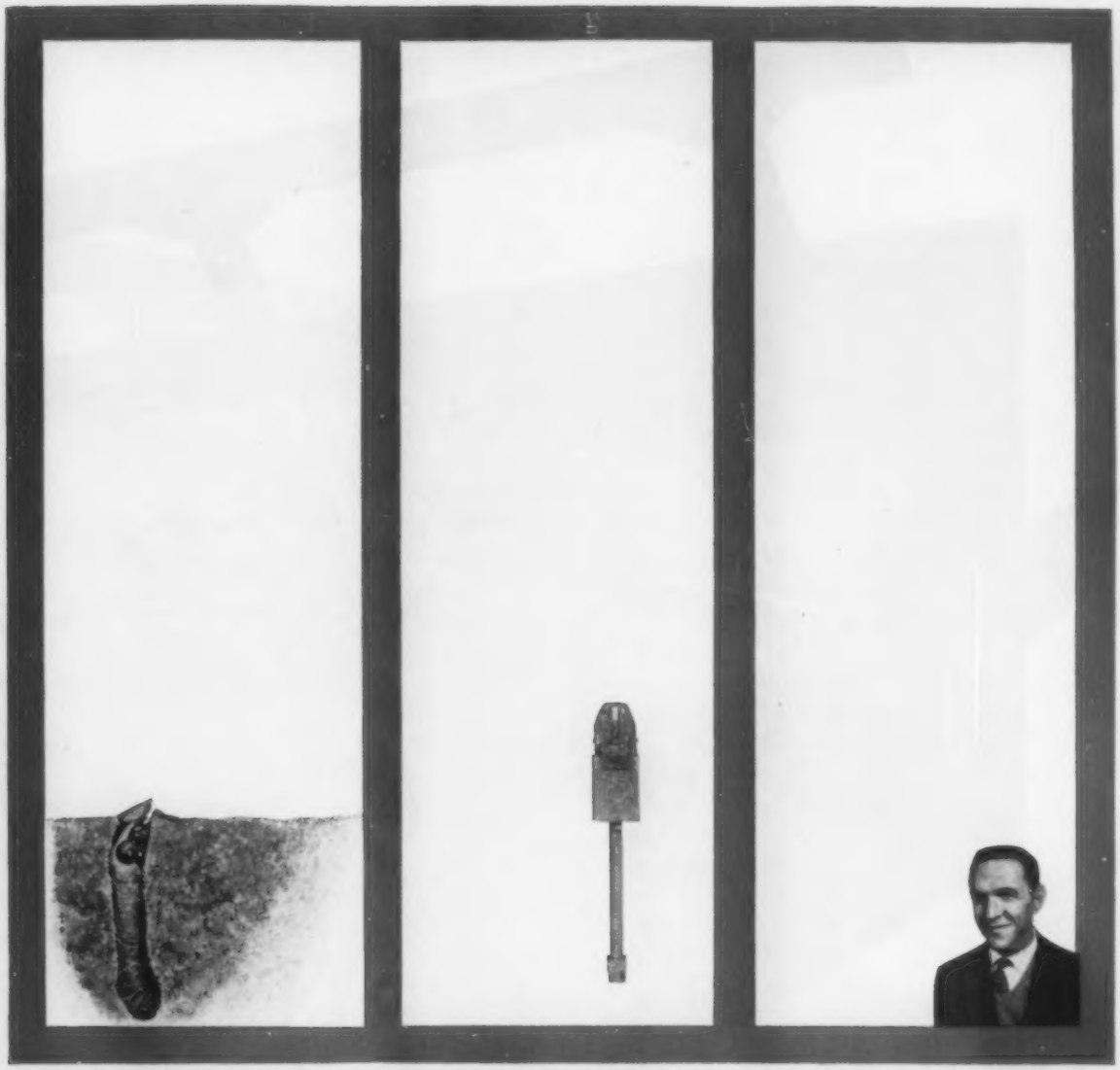
to automatically control flow of air, oil, chemicals and grinding slurries, without use of poppets or spools. Eliminates metal-to-metal contacts and metal-to-rubber seals. When valve is open, supply pressure through inlet port forces elastic rubber sleeve against tube, forcing media to flow around inlet plug and through outlet port. To close valve, pilot pressure is applied between inside diameter of tube and outer periphery of rubber sleeve. This collapses sleeve over rounded ends of inlet and outlet end plugs, sealing off supply pressure. Handles pressures up to 200 psi. For pipe sizes from ¼ to 12 in. Available normally open or normally closed. **Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.**

Circle 318 on Reader Service Card

Battery capacity is boosted . . .

for stationary service by up to 66% (at 8-hr rate) by introduction of tubular-type positive-plate. Industrial storage batteries are reported to have estimated life of 20 yr in float-charge service; to store more power in given space and to be more efficient for weight than conventional bat-

continued on page 74



Underground Spinner. Not all spiders make webs. But all are skillful spinners of strong silk thread, for very different uses ranging from aerial "parachuting" to wrapping up prey. The trapdoor spider digs a deep hole, spins a gossamer coating for it, adds a hinged lid and lives securely in his silk-lined, expertly engineered burrow.

Tiny Thread Transducer. In textile weaving this new Mark III thread transducer — shown greatly reduced in size — helps eliminate moirè patterns by recording average and cyclic thread tension. Friction in the transducer's floating arbor is overcome by three MPB bearings cycled between 10,000 and 20,000 rpm 371 times per minute.

Man With Miracles. Like all MPB Sales Engineers, Harry Gabriel can tell you about the advantages MPB bearings are bringing to new, miniaturized devices like the Mark III thread transducer, throughout the country. For miniaturization of your own products he can also give you expert aid in reducing friction and inertia with MPB bearings.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN THREAD TRANSDUCER SHOWN ABOVE

The more than 16,000,000 miniature and instrument bearings produced by MPB have met requirements in over 16,000 different types of applications. Developing bearings to aid in the design and manufacture of smaller, lighter, *better* components has always been a part of MPB service to customers. For details about MPB as a consulting and cooperating force — and for a catalog on MPB bearings, the world's largest line — write to **Miniature Precision Bearings, Inc.**, 910 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

CIRCLE 69 ON READER SERVICE CARD

X-A-R ABRASION RESISTANT STEEL

ARMS CUTTING BLADE WITH HARD, TOUGH EDGES

Steel

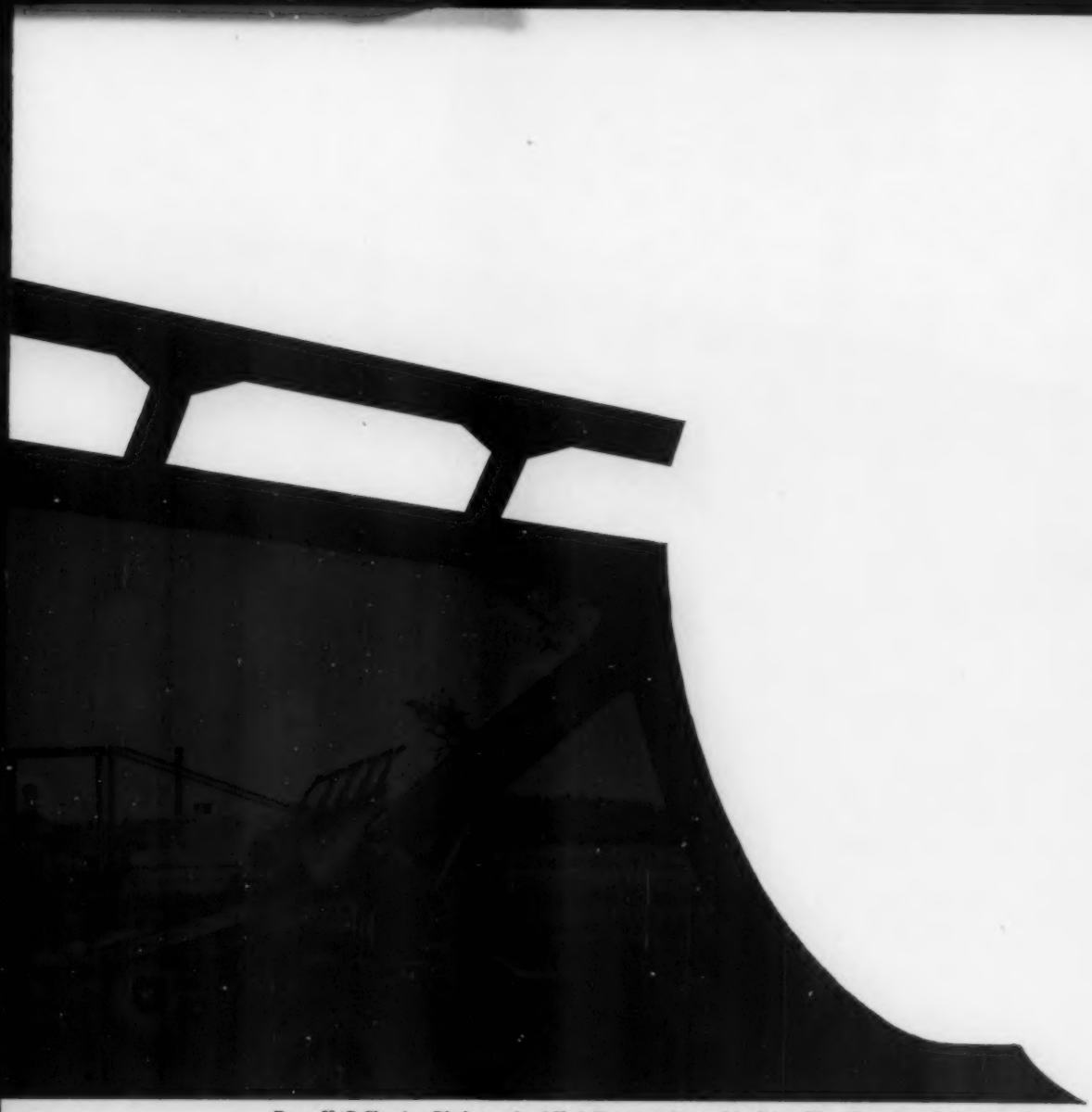
Look for the STEELMARK on the products you buy; place it on the products you sell.

The business end of this land-clearing blade takes a real beating from terrain and timber. It downs brush, trees of all sizes—everything in its path. Shears off stumps at ground level. Piles cut materials into windrows. Drives its stinger through sturdy large trees to split and weaken them. Cuts a wide swath below ground level to build V-type drainage ditches. Works long, hard and fast. ◆ The point of it all? Edges made from ¾" and 1" X-A-R 15 with a hardness of 360 BHN. X-A-R is the name for tougher, harder alloy steels developed by Great Lakes Steel especially to meet abrasion problems. They're made to work better and last longer wherever materials collide with equipment—as liners, teeth, bars, blades, and plates for example. *Under conditions that commonly wear out equipment in a hurry, X-A-R*

Great Lakes Steel is a division of

X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommun Metals & Supply Co. Los Angeles, California	Interstate Steel Co. Evanston, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania



Rome K/G Clearing Blades made of X-A-R—manufactured by Rome Plow Company, Cedartown, Georgia

FOR QUICK, ECONOMICAL LAND CLEARING

outwears any other type of steel. ◆ Close control during heat-treating, quenching and tempering is the secret of low carbon alloy X-A-R steels. And workability is as favorable as their hardness and toughness. Difficult problems, such as welding under cold conditions or extensive flame cutting, are handled well by X-A-R 30. For *extremely* difficult problems, choose X-A-R 15. ◆ X-A-R abrasion resistant steels, supplied in hardnesses from 360-400 BHN (or, by agreement, in lower Brinell hardnesses), are immediately available in ⅛″ to 1″ thicknesses, widths up to 72″ and lengths up to 35′. For complete technical information, write Great Lakes Steel Corporation.

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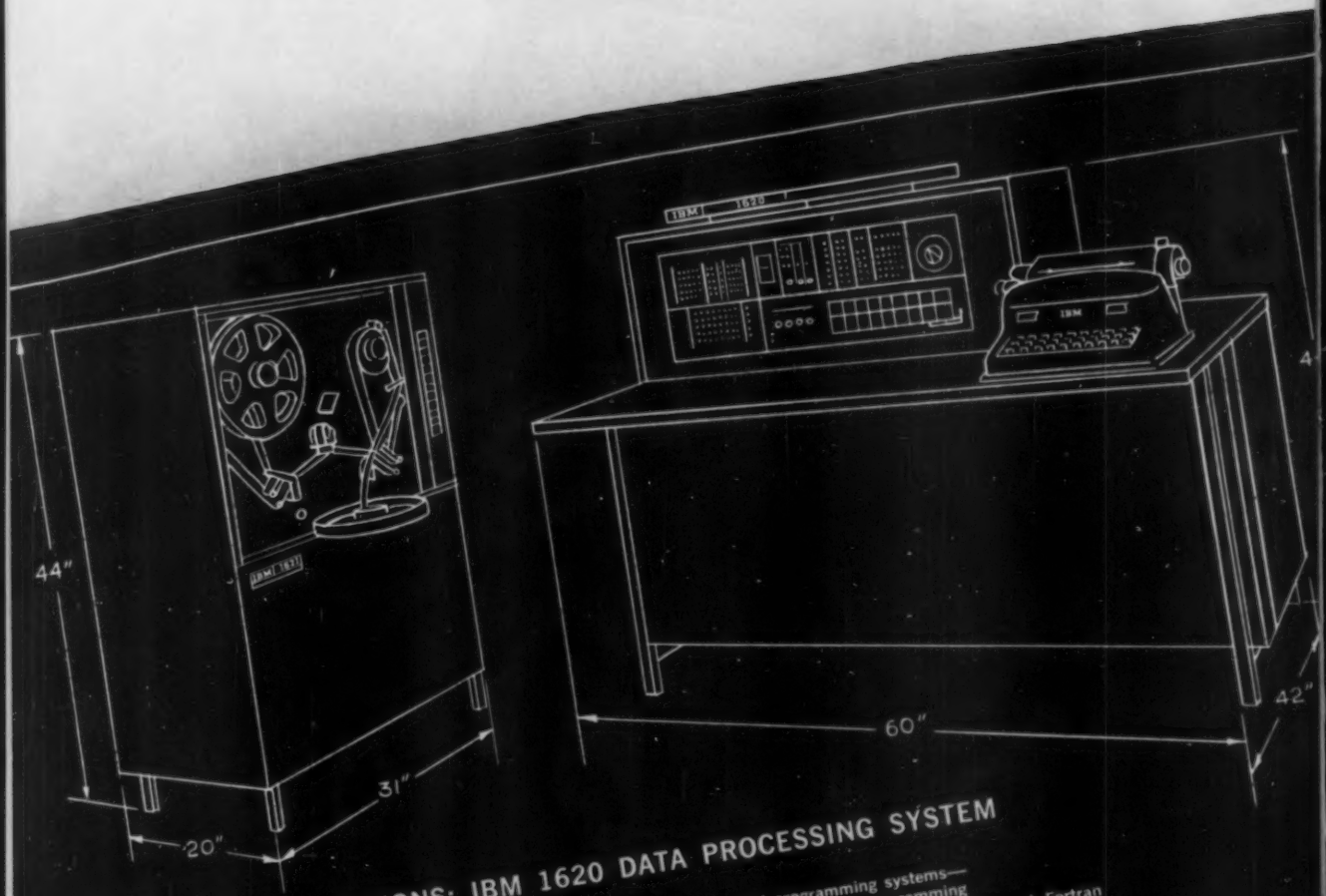
Salt Lake City, Utah

A. C. Leslie & Company, Ltd.
Montreal, Canada

CIRCLE 72 ON READER SERVICE CARD→



SPECIFICATIONS: IBM 1620 DATA PROCESSING SYSTEM

Core storage—20,000 digits
Automatic operation—stored programming
High computing speed—20 microsecond machine cycle
Powerful instructions with two data addresses
Decimal and alphabetic
Variable field and record length—any size numbers

Advanced programming systems—
Fortran and symbolic programming
Compatibility with other computers through Fortran
Simple console with logging features
Self checking throughout
Transistorized circuitry—
compact, economical, reliable
Paper tape input and output

The 1620 will meet technical computing requirements too complex for the conventional desk-type calculator. It provides many advantages of larger systems at a much lower cost. In addition, it can be used to support other data processing systems such as the IBM 650, 704, 705, 709, 7070 and 7090.

Information enters the system from the typewriter of the 1620 Central Processing Unit, or from the 1621 Paper Tape Reader. Output is to the typewriter or 961 Tape Punch.

Machine	Weight in lbs.	Current Requirements	Power cord	Interconnecting cable	Heat Load Specification BTU/Hr
1620	1,000	20 Amps., 115 Volts, single phase	10′ 3-Wire for 115 and 230 Volts	10′ signal	5,000
		10 Amps., 230 Volts, single phase		10′ power	
		6.5 Amps., 208 Volts, three phase	10′ 4-Wire for 208 Volts	—	2,000
1621	280	—	—	—	

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RELIEVES YOUR STAFF OF TIME CONSUMING WORK

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The 1620 is easy to learn, easy to operate, easy to communicate with. It adapts readily to specialized and general problems such as design development, blending problems involving matrix arithmetic, research calculations with differential equations. It facilitates the development of mathematical models for plant and shop operation, and evaluation studies employing statistical techniques such as regression analysis.

IBM also makes available a comprehensive library of mathematical routines and programs as well as reliable customer engineering. These services supporting the 1620 are an important part of IBM Balanced Data Processing. They make it easy for you to make full use of the 1620 in your operations without delay. Like all IBM data processing equipment, the 1620 may be purchased or leased.

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(engineering application)

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CITY _____ ZONE _____ STATE _____

teries, saving floor and mounting space and up to 55% in weight. Plates with square tubes, with patented Silvium grids, are 30 to 60% thicker than flat pasted plates. Teamed with positive plates are pasted negative plates that are 9 to 20% thicker than those used in other types of stationary batteries. Battery, assembled in transparent polystyrene jar, is available in 10 sizes, with capacities at 8-hr rate ranging from 200 to 800 amp-hr. **Exide Industrial Div, Electric Storage Battery Co, Rising Sun and Adams Aves, Philadelphia 20.**

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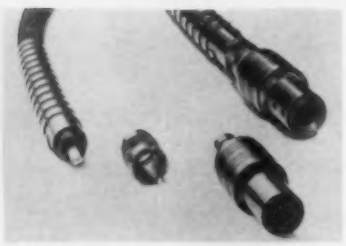

Quick-disconnect power drive flexible shafting . . .

uses spring-ball method for quick coupling or uncoupling at either power source or drive component. Shaft has built-in ball-bearing at each end and couplings that can be bored to suit and attached with set-screws. Available in ⅜, ½ or ¾ in. core, with max torque capacity of 220 in.-lb. Flexible shaft core is made of layers of music wire said to be assembled for high-speed operation and long life. Casing is lined with oil-tempered spring steel, reinforced with wire braid, covered with oil-resistant neoprene impregnated fabric and an abrasion-resistant rubber jacket. **Stow Mfg Co, 426 Shear St, Binghamton, NY.**

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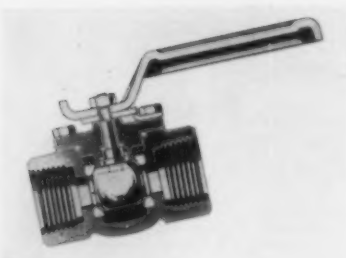

Bronze ball-valve line . . .

with screw ends and Teflon or Buna-N seats and seals is offered in pipe sizes of ¼ to 2 in. Top-entry design facilitates in-line maintenance. Removable cover exposes ball, which can be removed by using hook on valve handle, providing access to seats. Self-aligning ball rides on seats, sealing at high or low pressure without springs or bearings. Valves offer straight-through flow, low friction, quarter-turn operation. Stainless steel line is now being readied for marketing. **Lunkenheimer Co, Cincinnati.**

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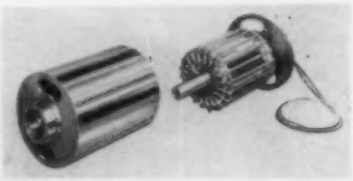
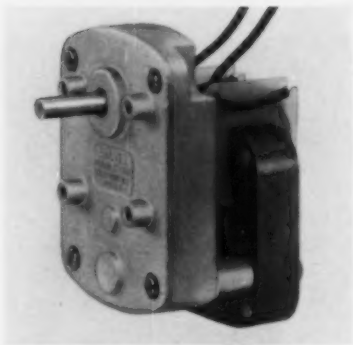


Heating roll . . .

is electrically heated with dual thermocouple temperature control. Also available with solution transfer medium. Available for any temperature level from 275 to 1000 F. OD of roll is chrome-plated and polished and measures from 6 to 30 in. **Thermel Inc, 9400 Robinson Rd, Franklin Park, Ill.**

Circle 322 on Reader Service Card



Enclosed helical gearmotor . . .

has field mounted directly behind gear housing. Motor has output speeds from 6 to 120 rpm with output running torques of 12 in.-lb at 6 rpm for continuous duty. Motor can be geared for speeds higher and lower than standard and wound for higher torques at intermittent loads. Brake or clutch can be built in without dimensional increase. **Brevel Products Corp, 639 W 26th St, New York 1.**

Circle 323 on Reader Service Card

High-temperature solenoid . . .

is hermetically sealed and has protective coating said to help achieve life rating of 1000 hr at 1000 F and to withstand temperatures to 1600 F. Plunger travel is 0.020 in. Unit weighs 0.28 lb. Available in rigid or flexible types. Reported to be priced lower than present nonhermetic units on the market. **Barber-Colman Co, Aircraft & Missile Products Div, Rockford, Ill.**

Circle 324 on Reader Service Card

Sealed-system pressure snubber . . .

protects pressure instruments against corrosion and plugging. Incorporated into downstream side of diaphragm seal, device is factory-adjusted to permit upscale or downscale equilibrium readings in about 2 to 3 sec. On systems with transient line surges or pulsations, porous metal snubber also prevents flow of corrosive materials into bourdon tube in event of diaphragm rupture. Snubber also restricts pressure actuating liquid or gas flow into atmosphere to low rate of flow and velocity, in case both diaphragm seal and bourdon tube are completely ruptured. **Chemiquip Co, 36 E 10th St, New York 3.**

Circle 325 on Reader Service Card

Horizontal-force mount . . .

isolates shock and vibration produced by machinery whose operation develops predominantly horizontal forces. Each mount handles up to 4000 lb static load. Equipment rests on top plate that rides on set of internal rollers and is laterally restrained by end-positioned neoprene springs. Springs are offered in various stiffnesses, permitting selection of spring-rate suited for forces and frequencies involved. Measures 10⅞ x 8 in. over-all and 1⅞ in. high. **Barry Wright Corp, 700 Pleasant St, Watertown, Mass.**

Circle 326 on Reader Service Card

Solenoid valves are cooler . . .

by 50 F in operation and offer reduced valve noise. Said to be one of the smallest in size for their capacity, ¼ or ⅜ in. pipe size valves are available in two- and three-way types, normally open or normally closed, for ac or dc operation. Max pressure range of two-way, ac, normally closed valve is 0 to 400 psi. Intermittent-duty coils for higher pressure ratings are available and can be furnished to operate to 1000 psi. Time delay, metering (45°, bottom, side or pipe connector), free-venting and three-way directional valves are also offered. Stainless steel construction. All standard two- and three-way types are UL-approved for general use. Standard valves handle vegetable and light oils, gasoline, inert gases, air and

continued on page 76

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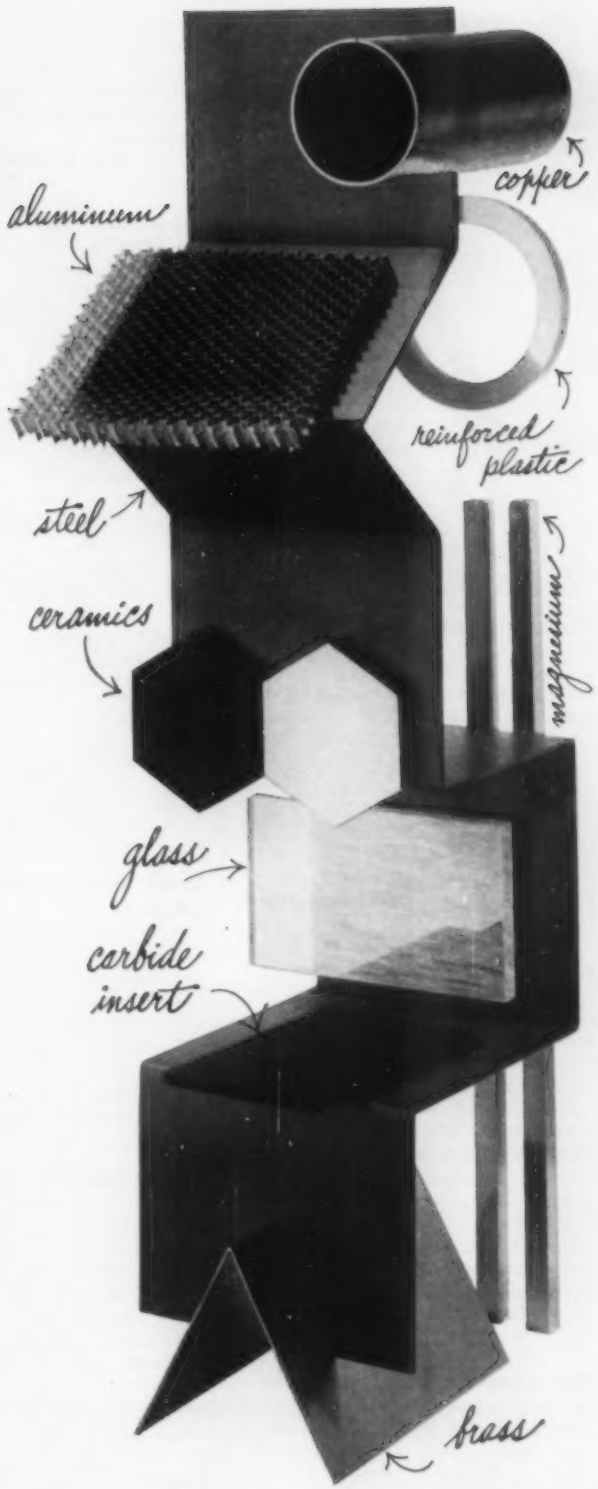

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

CIRCLE 75 ON READER SERVICE CARD 75

water at temperatures to 185 F. Coils with Class A, B or H insulation can be furnished, rated for max ambient temperatures of 221, 266 and 356 F, respectively. **Allied Control Co Inc, 2 East End Ave, New York 21.**

Circle 327 on Reader Service Card

Electronic chassis latch . . .

for small, 5¾-in. standard drawer offers positive latch and locking action. Latch housing, shaped to fit contours of the hand, can be used to carry drawer, irrespective of handle position. Over-all size of latch is 4.7 in. and extends 1.4 in. from face of chassis drawer. Provides 6¼ to 1 mechanical advantage for positive injection and rejection of drawer and allows ¼ in. travel or takeup. **Hartwell Corp, 9035 Venice Blvd, Los Angeles 34.**

Circle 328 on Reader Service Card

Waterproof electric counter . . .

is hermetically sealed, high-speed unit running to 2400 cpm or 40 cps in standard units and resetting electrically in 105 millisec. Counter can operate under water because electric reset mechanism is entirely enclosed within sealed case. Number wheels are set high in case for max visibility, with white figures, $\frac{7}{16}$ in. high, on black background. Said to meet Mil specifications 3272-A and other similar requirements. For use in severe industrial applications and where explosion-proof units are needed. **Durant Mfg Co, 1938 N Buffum St, Milwaukee 1.**

Circle 329 on Reader Service Card

Multiconductor contour cable

in various material combinations to meet temperatures from —85 to 482 F is available to meet military performance specifications for all types of harnesses. Flexible, flat cable, 0.012 in. thick, is etched in continuous rolls, in any length or width not exceeding 48 x 48 in., to match special circuitry configurations. Unshielded, electrostatically or magnetically shielded cable is available. Widths up to 5½ in. in conductor sizes from 20 to 28 ga with variety of spacing can be supplied. As many as 54 conductors per in. can be assembled in a single cable. **Hughes Aircraft Co, Industrial Systems Div, International Airport Sta, PO Box 90904, Los Angeles 45.**

Circle 330 on Reader Service Card

⅞-in.-dia, size-9 timer motor

is reported to withstand 8000 g axial shock and 500 g transverse shock. Can also withstand shock of dropping from 1 mi height. There is virtually no speed variation from —88.6 to 332.6 F because of special dry lubricating method. Gear train ratios range from 6:1 to 46,656:1. Up to 500 in.-oz peak loads can be handled. Life tests indicate performance of 2000 duty cycles at 100 in.-oz load or equivalent continuous running. At 100 in.-oz load, rpm ranges from 0.25 to 10, current at 77 F from 0.075 to 0.2 amp and unit length from 2.820 to 3.140 in. with gear train. Unit length is 1.406 in. without gear train. Also available as dc tach generator whose output is extremely linear with about 2 v output per 1000 rpm. **John Oster Co, Avionic Div, Racine, Wis.**

Circle 331 on Reader Service Card

Stock zinc or aluminum knobs . . .

to meet military standards are painted olive drab or navy gray, both with phosphorescent paint in index groove. Used on AN/GRC, AN/PRC, AN/TRC and similar equipment. Unless otherwise specified, tolerances are ±1/64 in. on fractions and ±0.005 in. on decimals. **Vemaline Products Co, Franklin Lakes, NJ.**

Circle 332 on Reader Service Card

Screw machine stock . . .

is reported to machine better than any of four standard screw stock aluminum alloys except 2011-T3. Guaranteed min yield strength of new alloy is said to be higher than typical yield strengths of any of the four standard alloys. Corrosion resistance and finishing characteritics are said to be as good as alloy 6061 and better than the other three. Alloy 6262, a member of the aluminum-magnesium-silicon family contains lead and bismuth for increased machinability. Min mechanical properties include 52,000 psi tensile strength, 48,000 psi yield strength and 5% elongation. Priced the same as alloy 6061-T6. Available in standard 12-ft lengths in round or hexagonal rod and bar. **Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.**

Circle 333 on Reader Service Card

Aircraft-type toggle switches

have ¼ in. wide electro-tinned brass, male tab connections for use with Burndy, AMP or Kent female connectors. Single and double throw units meet all applicable military specifications. Available in all circuit configurations for dc or ac applications up to 1600 cps. **Kulka Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.**

Circle 334 on Reader Service Card

Miniature temperature recorder . . .

operates directly from thermocouple, without signal amplification. Meter movement is calibrated to match thermocouple. Operates on 115-v ac line. Rear-mounted knob permits adjustment for thermocouple resistance. Min temperature span covered by recorder is 0 to 500 F; max span is 0 to 2500 F. Accuracy is reported to be 2% of full scale. Standard chart speed is 1 in. per hr driven by synchronous motor drive. Operates on pyrometer-with-clamper bar principle. Every 4 sec, pointer on moving coil is clamped briefly. Then marker on pointer prints pressure-sensitive chart paper without use of ink. Measures 3¾ x 5¾ x 4¼ in. deep. Weighs, with paper roll, 3½ lb. **Assembly Products Inc, Chesterland, Ohio.**

Circle 335 on Reader Service Card

16-lb tracing vellum . . .

is said to offer quality close to best deluxe vellum at one-third the price. Can be used as durable tracing paper for engineering, tracing, reproductions and for type-on masters. Made of 100% rag paper, impregnated with non-yellowing, non-migrating polymeric resin for lasting transparency. Paper formation is closed, dense and uniform. Has high tear strength. Supplied in cut sheet packages of 500 sheets and in 50-yd rolls. Can be preprinted to specifications. **Ozalid Div, General Aniline & Film Corp, 60 Corliss Lane, Johnson City, NY.**

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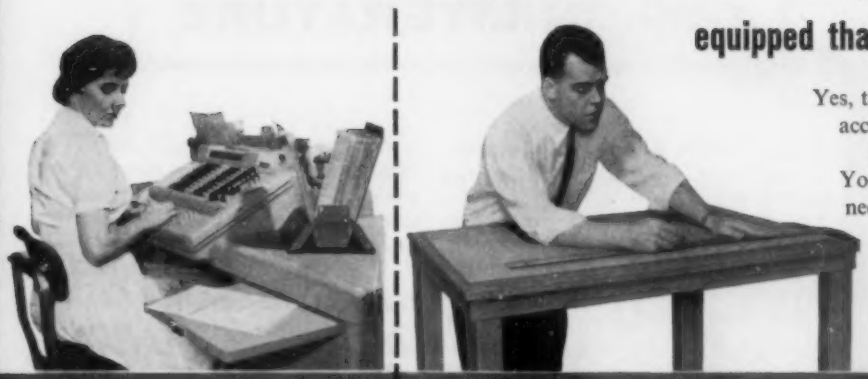
CIRCLE 77 ON READER SERVICE CARD→

(What's wrong with this picture?)



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Yes, today's bookkeeping procedures demand accuracy and productivity—equipment that guards against error, while saving time. Your professional engineer-draftsmen, too, need modern equipment for top efficiency, as their work helps establish your productivity throughout the *entire* product-planning and manufacturing cycle.

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Hamilton L-Contour Unit
Counterbalanced, range of board adjustments permits frequent position changes—at finger touch—offering greater flexibility of work arrangement, lessening fatigue. Telescoping legs adjust height 30" to 31". Generous storage facilities, durable linoleum reference surface. Beautiful utilitarian styling, maximum space efficiency, constructed for long service.

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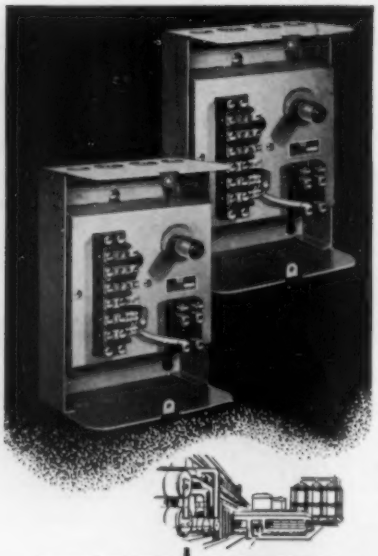

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DESIGN LITERATURE

The Gentle Art of Mathematics

DAN PEDOE. Macmillan Co, 60 Fifth Ave, New York 11. 5½ x 8½. 143. $3.95

If you're the kind of person who remembers all the probability formulas —until Junior asks you about them— or if you just like mathematical games and want an easy-to-read review of the simpler ones—this book is for you. It also covers Moebius bands, the basic principles of logic, and rational and irrational numbers. —ARG

Fundamentals of Engineering Graphics

MYRON G MOCHEL. Prentice-Hall Inc, Englewood Cliffs, NJ. 6 x 9, 379 pp. $8.50

This book illustrates methods for solving problems and presenting information graphically based upon the principles of mathematics and orthographic projection. Essential theory is pointed out and graphical applications are demonstrated. Continuity is established by developing complete projects instead of using a large number of nonrelated problems.

The Engineer's Vest Pocket Book

THOMAS, SPALDING and JAVLOVICH. Ottenheimer Publishers Inc, 4805 Nelson Ave, Baltimore. 2⅝ x 5½, 192 pp. 90¢

Reference material of a broad nature is included. Basic subjects covered are: mathematics, building, mechanics, heat, hydraulics, piping, electricity, surveying, costing, mining, chemical and miscellaneous.

Fundamental Formulas of Physics

Edited by DONALD H MENZEL. Dover Publications Inc, 180 Varick St, New York 14. 2 vol, 5⅜ x 8, 741 pp. $2 per vol.

Here is a compilation of formulas covering everything from the solution to a quadratic equation to the special theory of relativity. Each section has been written independently by a specialist in his field, so there is a certain amount of duplication, plus some variation in nomenclature. This is no problem if formulas were originally learned in a college course or from a textbook and no one is going to venture into an unfamiliar subject by first referring to the formulas used in that field. However, as a comprehensive deskside reference, these volumes (for engineers, particularly volume one) are worth their cost several times over.

Technical Illustration

T A THOMAS. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 8½ x 11½, 149 pp. $6.50

This book emphasizes practical, rather than theoretical techniques. Basic procedures used by industry to produce three dimensional drawings are discussed. Several chapters are devoted to a description of special mechanical equipment and its use. Numerous drawings illustrate procedures in a step-by-step fashion.

ABSTRACTS FROM THE LITERATURE

Timers

Describes units for making or breaking contacts, showing time elapsed during an operation, in-use time totals for machines, operating machines or processes for pre-set periods, varying set points with time, sequencing of single and multiple circuits.

"Timers." Instruments and Control Systems, Aug '60, 845 Ridge Avenue, Pittsburgh 12.

Nondestructive Testing

A discussion is presented of the interrelation of nondestructive testing and weldment quality. The characteristics of several nondestructive-testing methods to provide information necessary for the evaluation of weld quality are reviewed briefly. The views of several interested groups, as interpreted by the author, are considered.

"What the Welding Industry Requires From Nondestructive Testing," Jay Bland, General Electric Co; Welding Journal, Sept '60, 20th and Northampton Streets, Easton, Penna.

Research on Helical-groove Seals

Attempts to establish a theory on the helical-groove seal, based on the elementary functions governing the laminar flow of fluids. Some additions

continued on page 79

are made which are based on easily obtainable deductions provided by the method of electrical analogue computation.

"Machine Design and Calculation Research on Helical Groove Seals," by V. A. Zotov. Russian Engineering Journal, Issue No. 10, 1959, Production Engineering Research Association of Great Britain, Melton Mowbray, Leicestershire, England.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

ENCLOSED, FAN-COOLED, WORM GEAR DRIVES–Booklet, 32 pp. Lists AGMA standards to which units are rated, explains ratings and load information and gives descriptions and dimensions of 12 models. Foote Bros Gear & Machine Corp, Dept MJ, 4545 S Western Blvd, Chicago 9.

Circle 350 on Reader Service Card

WIRE AND STRIP CONSTRUCTION –Manual, 24 pp. Describes principal types of wire available for component construction, finishes, sizes and end-treatments, threading and forming treatments. Cites case histories. E H Titchener & Co, Custom Design Dept, 57 Clinton St, Binghamton, NY.

Circle 351 on Reader Service Card

HEAT-TRANSFER EQUIPMENT–Catalog 160, 32 pp. Covers radiators, heat exchangers, supercharger aircoolers, industrial and oil-field equipment and heating and air-conditioning products. Includes brief history of company, facilities and services and product resume. Young Radiator Co, Racine, Wis.

Circle 352 on Reader Service Card

INSTRUMENTS–Brochure 2, 20 pp. Contains basic specifications for pressure transducers, position instruments, accelerometers, and instrument/systems. Includes typical applications, features and operating principles. Bourns Inc, Instrument Div, 6135 Magnolia Ave, Riverside, Calif.

Circle 353 on Reader Service Card

PRECISION TEST INSTRUMENTS–Short catalog ES-9, 24 pp. Specifications and applications of instruments for automatic measurement of sound, vibration and strain. B & K Instruments Inc, 3044 W 160th St, Cleveland 11.

Circle 354 on Reader Service Card

DRAFTING PENCILS, LEADS AND HOLDERS–Catalog 1960, 20 pp. Describes and illustrates 81 items. Contains

continued on page 80

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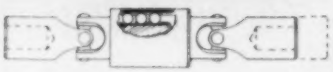

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SUBMINIATURE SWITCHES—Catalog 20-1, 16 pp. Covers commercial, high-temperature, military and environment-free subminiature switches. Pictorial index shows location of dimensional drawings, descriptions, force and movement specifications, electrical ratings and photo for each switch. Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.
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MECHANICAL ADJUSTABLE-SPEED DRIVES—Bulletin GEA-6806, 16 pp. Discusses operation, configurations, features, mounting positions, and ratings of ¼ to 25 hp mechanical adjustable-speed drives. General Electric Co, Schenectady 5.
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ELECTROMAGNETIC DRIVES—Booklet B-7875, 12 pp. Describes how electromagnetic drives work, what they include and where they are used. Discusses operating functions and mechanical features of various types of drives. Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.
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3000-PSI HYDRAULIC CYLINDERS—Supplement to bulletin 22A, 16 pp. Dimensions, dimensional drawings and specifications of hydraulic cylinders for continuous use in 3000-psi operating systems and any over-pressure or shock loads. Pathon Mfg Co, Cincinnati 12.
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BINARY ENCODERS—Brochure SP9-2, 12 pp. Describes specifications of shaft position encoders, many of which are basically binary time code generators or clocks that present output signals representing specific times. A W Haydon Co, 232 N Elm St, Waterbury 20, Conn.
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DUCTILE IRON—Bulletin 131-B, 20 pp. Covers features of ductile iron, as well as the company's facilities, manufacturing and quality control for the processing of this metal. Brillion Iron Works Inc, Brillion, Wis.
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GEAR-AND-PINION COMBINATIONS—Catalog 3001-B, 10 pp. Engineering drawings andtables describe integrally cast gear and pinion combinations available from stock dies. Gries Reproducer Corp, 400 Beechwood Ave, New Rochelle, NY.

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REDUCED-VOLTAGE STARTERS—Bulletin GEA-6860, 8 pp. Describes line of reduced-voltage starters, applications and operation. Contains selection and comparison table covering various types of starters and typical wiring diagrams. General Electric Co, Schenectady 5.

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STANDARD FLEXIBLE-SHAFT ASSEMBLIES—Form 574, 8 pp. Specifications and ratings of standard flexible-shaft assemblies. With dimensional drawings. F W Stewart Corp, 4311-13 Ravenswood Ave, Chicago 13.

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FLUID-POWER EQUIPMENT—General bulletin 10-001, 8 pp. Specifications, performance and application information for gear pumps, control valves and motors. Photos and cutaway drawings illustrate construction and design features. Hydreco Div, New York Air Brake Co, 9000 E Michigan Ave, Kalamazoo, Mich.

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MAGNETIC-REED SWITCHES—Bulletin, 6 pp. Contains descriptions and specifications of models DRG-1 and DRS-5 and charts and diagrams on actuation methods and mechanism. Hamlin Inc, Lake and Grove Sts, Lake Mills, Wis.

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METALLIZED PAPER CAPACITORS IN EPOXY TUBES—Data sheets, 2 pp each. Electrical specifications, temperature characteristics curves, sizes and part numbers for Series WE capacitors (for ac and dc network applications) and Series

continued on page 83

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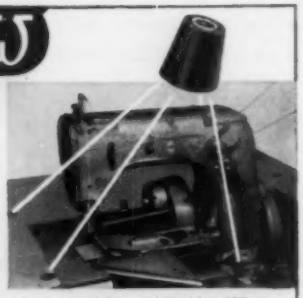

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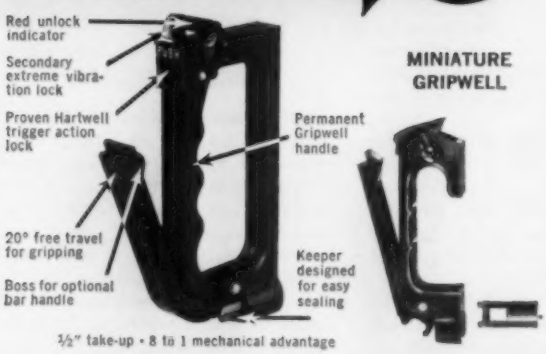
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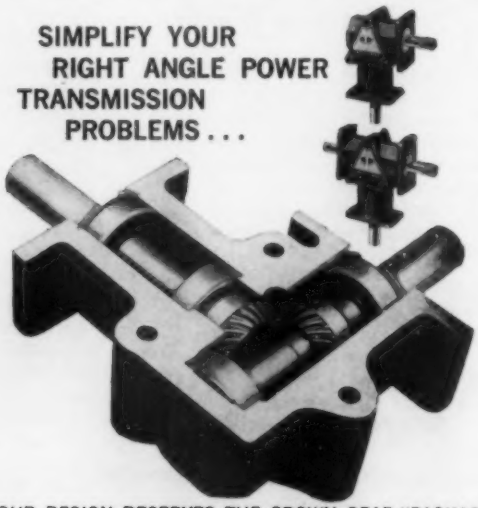

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Circle 371 on Reader Service Card

THERMOSTATS—Bulletins 6100 and 1000, 2 pp each. Describe line of MX thermostats featuring narrow differentials and Type S bimetal thermostats. Give ratings, construction and application information. With photos and schematic diagrams. Stevens Mfg Co Inc, PO Box 1007, Mansfield, Ohio.

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ELECTRONIC SWITCHES—Data sheet 177, 2 pp. Ratings, characteristics, dimensions and mounting information about electronic switch-circuit package that produces bounce-free voltage output from a mechanical switch. Micro Switch, Freeport, Ill.

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ROTARY MULTIPOLE SWITCH—Bulletin 22, 2 pp. Information on rotary switch that controls up to 75 poles with single knob. Includes electrical ratings, photo, dimensional and assemblage drawings, and mechanical specifications. Electro Switch Corp, King Ave, Weymouth, Boston 88.

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MAGNETIC LATCHING RELAY—Bulletin BR-594, 2 pp. Electrical and mechanical specifications of relay series. Illustrates standard mounting configurations. Babcock Relays Inc, 1640 Babcock Ave, Costa Mesa, Calif.

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METER FOR LOW-FLOW MEASUREMENT—Bulletin 10A4135, 2 pp. Covers dimensions, materials of construction, operation, capacities and optional accessories for miniature flowmeter for measurement of low flow rates of liquids or gases. Fischer & Porter Co, 628 Jacksonville Rd, Warminster, Penna.

Circle 376 on Reader Service Card

MAGNETIC PICKUPS—Bulletin CMP-50, 4 pp. Explains how self-generating input devices can be used for accurate mechanical-electrical conversion. Selection guide chart is included. Also contains typical curves, block diagrams. Electro Products Laboratories, 4501 N Ravenswood Ave, Chicago 40.

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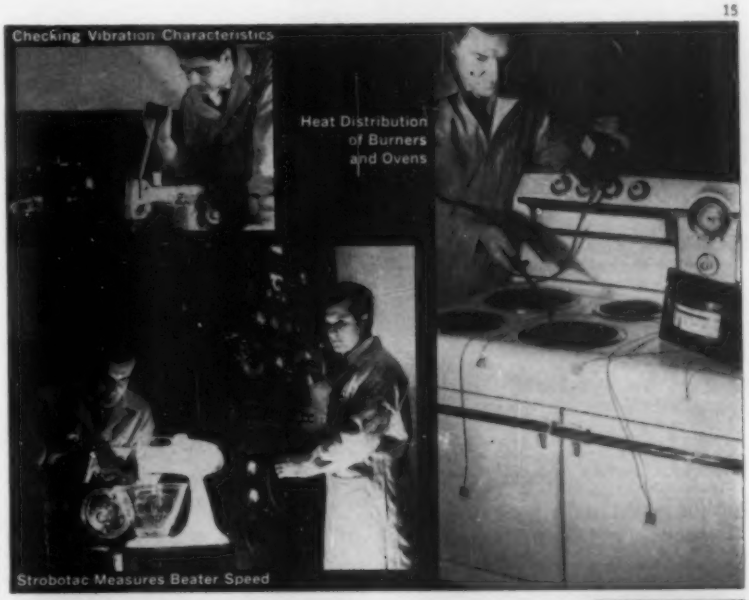

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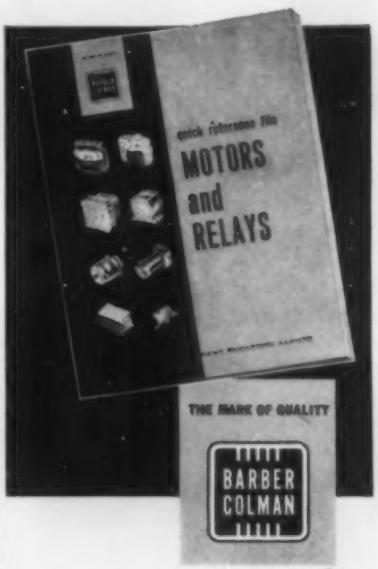

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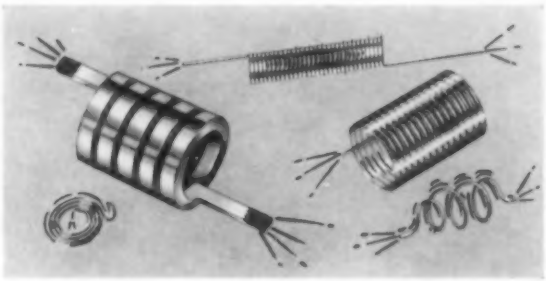

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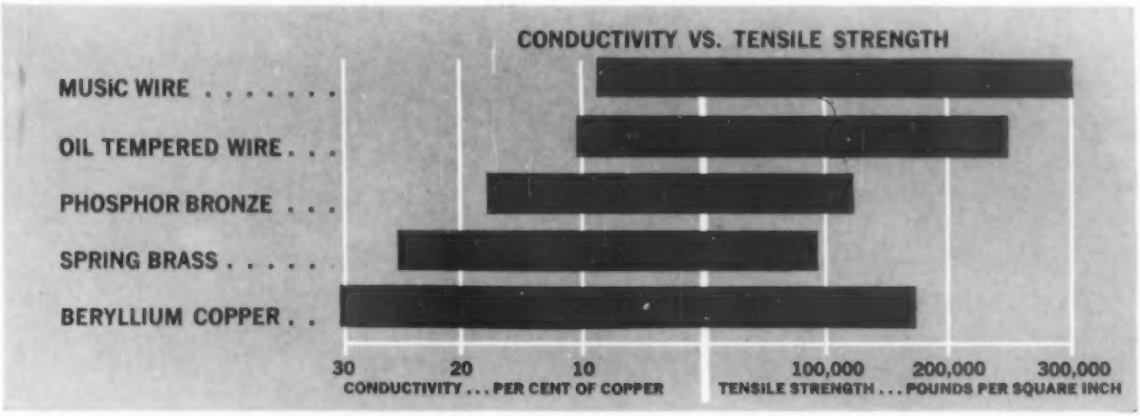
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MUSIC WIRE . . . . . .
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SPRING BRASS . . . . .
BERYLLIUM COPPER . .
30
20
10
CONDUCTIVITY . . . PER CENT OF COPPER
100,000
200,000
300,000
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